

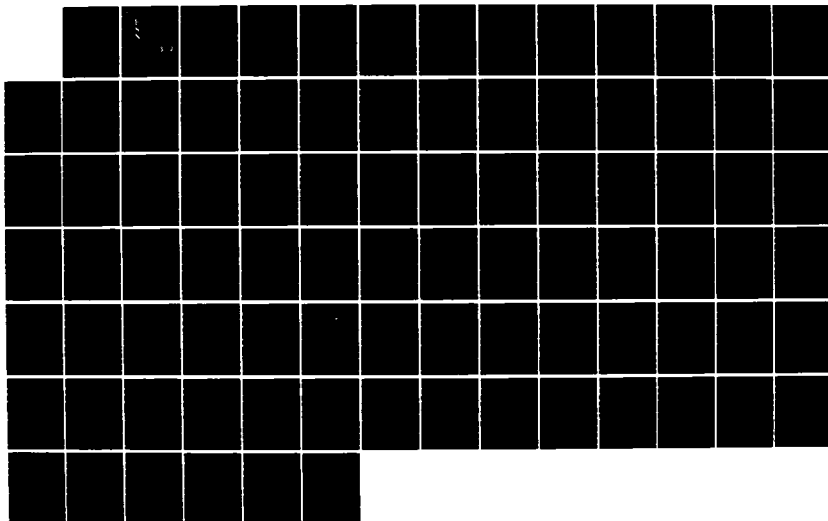
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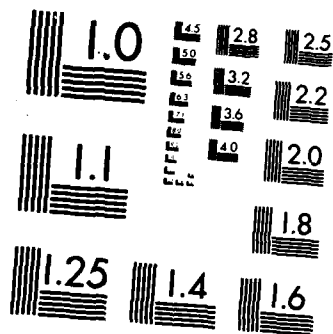
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Vol 40 No. 11-12/November-December 1986

# European Science Notes

AD-A173 371

|                               |            |
|-------------------------------|------------|
| <u>Behavioral Sciences</u>    | <u>399</u> |
| <u>Biological Sciences</u>    | <u>405</u> |
| <u>Computer Sciences</u>      | <u>411</u> |
| <u>Environmental Sciences</u> | <u>419</u> |
| <u>Material Sciences</u>      | <u>425</u> |
| <u>Mechanics</u>              | <u>433</u> |
| <u>Ocean Sciences</u>         | <u>440</u> |
| <u>Physics</u>                | <u>451</u> |

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# European Science Notes

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Editor ..... C.J. Fox

November/December 1986  
Volume 40  
Number 11/12

## Behavioral Sciences

- Conference of the International Society  
of Political Psychology... *Conference, 2nd* ..... William D. Crano 399

Laboratory and field studies were presented at this conference in the discussion of research on the factors that influence people's definition of friend and enemy. The conference, held in Amsterdam, was characterized by a wide variety of research approaches and methodologies, theoretical controversies, and practical concerns.

## Biological Sciences

- Second International Workshop on  
Neuroimmunomodulation ; ..... Claire E. Zomzely-Neurath 405

Topics of this workshop at Dubrovnik, Yugoslavia, in June, included neuroendocrine correlates of neuroimmunomodulation; enkephalins-endorphins; immunomodulators; neuroendocrine receptors in the immune system; natural mediators and pharmacology of neuroimmunomodulation; neurophysiological correlates of neuroimmunomodulation; stress and immunity; behavior associative learning and immunity; psychiatric and neurological disorders with immunological features; and cancer, AIDS, and immunity.

## Computer Sciences

- ESPRIT Update ; ..... J.F. Blackburn 411

The ESPRIT program has moved into the second half of its first 5-year phase. As confirmed during its own mid-term review in fall of 1985, it has made substantial progress in some areas. ESPRIT's background, present status (including some of its major achievements), and plans for ESPRIT II are reviewed here.

- The Second Alvey Conference. 30 June-4 July ..... J.F. Blackburn 414

The 5-year Alvey Program has 2 more years to run. Much progress has been made, and the author of this report believes that the collaboration fostered by Alvey between the UK's universities and manufacturers will play an important part in the UK's future success in the European market for IT products.



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## Environmental Sciences

- International Conference on Optical and Millimeter Wave Propagation and Scattering in the Atmosphere ; ..... Jerome Williams 419

Presentations at this conference in scintillation theory, imaging and transmission, remote sensing, nonlinear effects, and particle scattering are reported. Although a major portion of the science reported was by US scientists, it was obvious that scientists from other countries are making important contributions both in theory and experiment.

## Material Sciences

- Ion Beam Modification of Materials, IBMM 86 ..... Louis Cartz 425

Topics at the IBMM 86 conference included ion implantation in semiconductors, insulators, ceramics, and metals. There were also sessions concerning energy deposition and ion ranges, ion beam mixing, reactive ion etching, and amorphization by ion beams. This article focuses on papers dealing with surface microstructure, ion beam mixing reactions, enhanced adhesion, and ion projection lithography.

- Tribology Research at the Metal Research Institute of TNO ; ..... Irwin L. Singer 429

Tribological research at TNO's research in failure mechanisms, application of lubricants, application to coatings, and friction and wear behavior of polymeric materials are covered in this article.

## Mechanics

- European Turbulence Conference ; ..... Eugene F. Brown 433

This conference held in July in Lyon, France, was the first of a series which are planned to take place every 2 years. The presentations covered in this article are grouped in the areas of turbulence structure, nonequilibrium boundary layers and transition; geo- and astrophysical turbulence, and riblets and large eddy breakup devices.

- Fluid Mechanics Research at Selected Portuguese Universities in Portugal ; ..... Daniel J. Collins 436

Fluid mechanics research in Portugal is directed to wind machines, wave energy generators, fire research, and vehicle drag. This review of Portugal's university institutions and work covers the Instituto Superior Tecnico and the Universities of Coimbra, Aveiro, and Oporto.

## Ocean Sciences

- Columbus Ocean Workshop ; ..... Jerome Williams 440

This workshop was devoted to development of a consensus among UK scientists on what oceanography-related sensors should be flown aboard the Columbus portion of the Polar Platform.

(European Assoc. of Remote Sensing Laboratories)

|                       |                 |     |
|-----------------------|-----------------|-----|
| EASEL Symposium ..... | Jerome Williams | 443 |
|-----------------------|-----------------|-----|

This article addresses the presentations concerning marine applications of satellite data which were given at the EASEL Symposium. The symposium proved to be an ideal opportunity for the European remote sensing community to evaluate its current status and its future.

|   |                 |     |
|---|-----------------|-----|
| Satellite Observations of Ocean Color<br>for Dynamics and Biological Studies;<br>Presentations at the 26th Meeting<br>of COSPAR ..... | Jerome Williams | 447 |
|---|-----------------|-----|

Presentations on the topic of ocean color are discussed under the headings of chlorophyll determinations, suspended sediments and gelbstoff, chlorophyll by fluorescence, primary productivity, chlorophyll as a tracer, and ocean color.

## Physics

|   |            |     |
|---|------------|-----|
| Laser Spectroscopy Serves Basic Research<br>at the University of Graz ..... | Paul Roman | 451 |
|---|------------|-----|

Applied Raman spectroscopy and high time-resolution laser fluorescence studies are vigorously pursued in the two laser-spectroscopy groups of the Department for Experimental Physics at the University of Graz. Research with manmade organic molecules, arranged in two-dimensional structures, may pave the way to applications in molecular electronics.

|  |            |     |
|--|------------|-----|
| The 6th European Symposium on Optoelectronics -<br>A Mixed Bag ..... | Paul Roman | 453 |
|--|------------|-----|

Fiber optics (both for communication and for sensor systems), optics and optoelectronics (including new materials), laser development and applications for research, and optoelectronic displays and imaging systems were the topics of a 3-day meeting in Paris. A large exhibition gave the framework for the conference.

## News and Notes

|   |                          |     |
|---|--------------------------|-----|
| ONR Branch Office, London Has Sponsored<br>a Session on the Fundamental<br>Physics of Microstructures .....   | Paul Roman               | 457 |
| WOPLOT 86: An Unusual Multidisciplinary<br>Workshop on Parallel Processing .....                              | Paul Roman               | 458 |
| Second International Symposium on Analysis<br>and Detection of Explosives .....                               | A.N. Garroway            | 459 |
| The Second International Meeting on<br>Chemical Sensors .....   | John F. Giuliani         | 461 |
| Ionic Transport Will Be the Topic<br>of 1987 Meetings .....   | David L. Venezky         | 462 |
| International Symposium on the Properties and<br>Applications of Metal Hydrides;<br>State of the Theory ..... | D.A. Papaconstantopoulos | 463 |
| Conference on New Materials and Their<br>Applications, September 1987 .....                                   | Louis Cartz              | 464 |
| "Radiation Effects in Insulators--4" .....  | Louis Cartz              | 465 |
| Acoustics Research at EDF .....   | Eugene F. Brown          | 465 |

|  |                           |     |
|--|---------------------------|-----|
| Third International Symposium on the<br>Applications of Laser Anemometry<br>to Fluid Mechanics ..... | Daniel J. Collins         | 467 |
| Coastal Engineering at the Technical<br>University of Denmark .....                                  | Jerome Williams           | 468 |
| Geophysical Fluid Dynamics at<br>Cambridge University .....  | Jerome Williams           | 469 |
| Oceanography at the University of Copenhagen .....   | Jerome Williams           | 470 |
| A New Journal: <i>Brain, Behavior,<br/>and Immunity</i> .....  | Claire E. Zomzely-Neurath | 472 |
| ONRL Cosponsored Conferences .....   |                           | 472 |
| ONRL Reports .....   |                           | 472 |
| Science Newsbriefs .....   |                           | 473 |
| Military Applications Summary Bulletins .....  |                           | 473 |
| Overseas Travelers .....   |                           | 473 |
| Year End Index .....   |                           | 475 |

\* \* \*

## Behavioral Sciences

### CONFERENCE OF THE INTERNATIONAL SOCIETY OF POLITICAL PSYCHOLOGY

by William D. Crano. Dr. Crano is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Texas A&M University, where he is Professor of Psychology.

The ninth annual conference of the International Society of Political Psychology was held in Amsterdam from 29 June to 3 July. The theme of this year's conference was the psychological dimensions of peacemaking and peace building. Given the inclusive nature of this general orientation, it was not surprising that the 5-day meeting was characterized by a noteworthy variety of research approaches and methodologies, theoretical controversies, and practical concerns. At the most basic level, studies focused on the physiological bases of violence and aggression were discussed, and the implications of this research for constructive political behavior were drawn. From the fundamental social psychological perspective, the factors that influence the perception of in-group vs. out-group ("us vs. them") membership were reported. Careful, precise, laboratory and field experimentation was presented in the discussion of research on the well-studied but still open question of the factors that influence people's definitions of friend and enemy.

At a somewhat intermediate point between basic and applied concerns, political scientists and psychologists discussed the effects on public opinion of various events in the "world theater," the public-relations orchestration of such events, and the demographic and personal factors that influence reactions to them. At the most applied level were discussions of recent attempts to bring psychological principles to bear in mediating the Arab-Israeli conflict, and of the successes and ultimate failure of the Dutch peace movement in its campaign to forestall the installation of cruise missiles in the Netherlands. The variety of research styles, methods, and substantive considerations made for an extremely interesting, if at times somewhat uneven, series of presentations.

Some indication of the importance that the Dutch attached to this event may

be gathered from the fact that the conference was opened by the deputy mayor of Amsterdam, the Hon. Walter Etty, who shared the podium with Dr. Manfred Lachs of the International Court of Justice in The Hague. Dr. Lachs' discussion of the role of the international court and of the disputes with which it has had to contend over the years provided a valuable and realistic backdrop for the research and theory presented over the course of the convention. As further evidence of esteem with which the Dutch hold the International Society of Political Psychology, the Dutch Minister of Defense, J. de Ruiter, presided over the closing ceremonies.

The sessions were well-attended by scientists from almost all of the nations of Western Europe, along with representatives from the USSR, People's Republic of China, N. Korea, Israel, Libya, Canada, US, Australia, and New Zealand. An African presence was provided by a very innovative approach: A "debate" was staged between participants from Ghana, Kenya, and Uganda, whose video-recorded views of the conflict between the third world nations and the industrialized countries served as the stimulus for a response by scientists from the west. The debate was cochaired by the Dutch Ambassador to Kenya, J.F. Boddens Hosang, and S. Tuginie, the Tanzanian Ambassador to the Netherlands.

Inasmuch as eight sessions were held simultaneously, twice each morning and afternoon, it was impossible for one reporter to witness and summarize firsthand all that was presented. Although some summary papers were available, not all scientists made their research available in print. Accordingly, what follows is a selective review of the material presented in the sessions that I attended, and that I judged to be of potential interest to the readership of ESN. I hope that my choices and decisions, necessitated by the Aristotelian proposition that a single person cannot be two places at the same time, will say more about the conference than about the author of this report.

#### Basic Research: Some Representative Examples

Administrative Aggression. Controversy has proved a constant companion of research on obedience to authority ever since Milgram's (1963) ground-breaking demonstrations of nearly a quarter-century ago, despite the fact that the basic findings have been replicated in the US, Spain, Germany, Jordan, Australia, Italy, West Germany, and the Netherlands. It will be recalled that Milgram demonstrated people's apparent willingness to

administer powerful, even fatal, electric shocks to another (1) when they were told that their actions were a necessary part of a scientific procedure, and (2) when the scientist in charge of the project insisted that they continue despite the victim's expressed desires to quit the study.

Critics of this line of research have argued that the scientist's insistence on the continued administration of punishment operated as a tacit guarantee to the subject that no serious long-term harm would come to the victim. As such, the relevance of the obedience research for situations involving real consequences has been called into question.

At the Amsterdam meetings, Meeus and Raaijmakers (Faculty of Social Sciences, University of Utrecht, the Netherlands) discussed their research on "administrative aggression," in which more realistic and less archaic forms of violence (but violence, nonetheless) are imposed on one individual by another. In this research, naive subjects play the role of a test administrator, and they are led to believe that the test will determine whether or not the (unemployed) testee will be hired for a sought-after job. The subject/administrator is persuaded to interpose distracting and discouraging remarks during the testing, on a prescheduled basis, to determine the effects of stress on test performance. The stress manipulation is described as part of a psychology department project, which is independent of the real job to which the applicant aspires.

In the course of the study's introduction, the subject/administrator "overhears" the applicant agree to receive continuous feedback on his test performance, so long as it does not have a negative effect on performance. To the applicant, the experimenter insists that feedback will not attenuate performance, despite the fact that quite the opposite was suggested to the test administrator.

As the test begins, it is clear that the applicant will pass. Then, the extraneous stress remarks begin, and performance begins to deteriorate. The psychophysical monitors attached to the applicant indicate to the administrator that the stress remarks are having a powerful influence. Midway through the test, the applicant begins to object to the administrator, and ultimately rescinds his consent to receive performance feedback. The experimenter, however, insists that the test administrator continue as planned.

The results of the study are startling: More than 90 percent of the 24 subjects who played the role of administrators continued to provide distract-

ing false feedback to the applicant despite the fact that (1) a real job was (apparently) at stake, (2) the unemployed job applicant would fail the test if the feedback continued beyond the point at which he raised his strenuous objections, and (3) the test would have posed no problem if the false feedback had not been administered. None of the 15 control subjects who received no encouragement by the experimenter to maintain the disruptive feedback persisted after the applicant's objection. Pitting the real-life needs of the unemployed job-seeker against the somewhat questionable goals of the scientist resulted in a finding completely consistent with those of Milgram.

In a later study, potential test administrators were given a description of their role 1 week before the experiment actually began. This time for contemplation did not moderate the "obedience to authority" response. Indeed, all of the 15 subjects in this experimental variation of the research design persisted to the very end of the reinforcement series. Despite the fact that an important real-life outcome depended upon their acting in a humane fashion (unlike, some have argued, the circumstances surrounding the original Milgram study), subjects appeared willing to comply with the demands of the authority. A more complete description of this program of research can be found in Meeus and Raaijmakers (1986).

Social Dilemmas. A social dilemma is a choice situation in which an action that maximizes one's own payoff is accomplished at the expense of the other members of one's group. Social dilemmas are pervasive features of the topography of everyday life. As such, they have come under the increasingly intense scrutiny of social scientists. As an example of a social dilemma, consider the following scenario. In times of drought it might benefit individual homeowners to water their lawns; however, such an action would prove detrimental to the community at large, for whom the attendant water shortage would be exacerbated. Indeed, if all members of the community acted in a selfish manner, the water supply might be lost completely. The dilemma involves the choice between an egocentric and an altruistic act. Hardin (1968) formally described situations of this type as a "tragedy of the commons." His work was foreshadowed by Wiesner and York (1964), whose discussion dealt with the social dilemma that pitted the signing of the Nuclear Test Ban Treaty against national security needs.

Early discussions of social dilemmas despaired of a technical solution to

these puzzles, calling instead for a recognition that only ethical solutions could resolve the apparent antagonism between self-interest and altruism. More recent thinking has postulated various linear additive utility functions, weighted to reflect (nonnegative) payoffs to the individual and the group. One interesting approach of this type is exemplified in the work presented by Ksien-sik and Wendt (Christian Albrechts University, Kiel, West Germany), who make use of factorial experimental designs to test a multiattribute utility function in predicting behavior in choice dilemmas. In two studies, these researchers investigated the interplay of the effects of one's initial costs in acting on behalf of the group, the number of others who would benefit from the altruistic response, and the number of others also willing to make such a prosocial choice, on individuals' decisions in a social-dilemma choice situation. The fit of data with model-produced expectations was not perfect. However, one very interesting finding was the consistency with which subjects applied their individual decision rules in different dilemma contexts. Thus, if in one setting a person was strongly influenced by the number of others who would benefit from an altruistic act, he or she would likely be influenced by this consideration in entirely different choice contexts. Continued work on this issue promises to isolate the major parameters that drive decisions and behavior in social dilemmas, and the individual difference factors that influence the differential weighting of these parameters.

#### Survey Research on Perceptions of Friends and Enemies

Images of "Outsiders." The Dutch have traditionally entertained a view of themselves as a hospitable people whose tolerance of outsiders reflects their own love of liberty. Indeed, in the 1960's, national polls showed that 86 percent of the respondents did not object to foreigners as neighbors. In 20 years, this majority has withered, so that today only 48 percent of the population is willing to take the prosocial position. Among the less-than-high-school educated Dutch, more than 50 percent hold negative attitudes toward foreigners. This shift in public opinion has resulted in a flurry of ethnographic self-examination in the Netherlands, where national surveys appear to follow on the heels of one another. Although this development might prove burdensome for the Dutch, who as respondents must bear the brunt of the research, for social scientists it rep-

resents a veritable Valhalla of promising data.

One interesting example of Dutch survey research whose results have both theoretical and practical implications was reported by Hagendoorn (University of Nijmegen, the Netherlands). In his study, Hagendoorn assessed the attitudes of approximately 300 college and high school students toward seven ethnic minority groups in the Netherlands (Moluccans, Surinamers, Spaniards, Moroccans, Jews, Turks, and English). Data were collected both on the respondents' evaluations of these groups and the extent to which they wished to maintain distance between themselves and the ethnic groups across a set of social activities. The activities ranged across a broad band of possible interactions, from "having X (e.g., a Spaniard) as a colleague," "a neighbor," "a physician," to, at the most intimate level, "a marriage partner."

Analysis disclosed that respondents whose evaluative scores indicated a high degree of ethnocentrism displayed a clear hierarchical structure of social distance preferences across the various social activities. For each activity, ethnocentric respondents' ordering of the ethnic groups (in terms of distance preferences) was constant. This result might be expected on the basis of past literature. However, an intriguing addition to the results was Hagendoorn's finding that this "ethnic hierarchy" was also characteristic of students whose attitude scale scores indicated very little ethnocentrism. All respondents differentiated the "out-groups" in a consistent fashion. This is not to say that the absolute amount of preferred social distance was the same for ethnocentric and nonethnocentric respondents, but rather that their respective social-distance hierarchies were indistinguishable.

Three hypotheses were advanced as possible explanations of these results. Social contact theory holds that we discriminate against those we do not know. (The Dutch proverb, "unknown makes unloved" summarizes this possibility, and corresponds well with our own "out of sight, out of mind.") Social contact theory suggests that by enlarging the realm of interpersonal contacts, we will attenuate prejudice. The two other possibilities proffered in explanation of the hierarchical social preference findings were based on perceived cultural differences, and perceived differences in socioeconomic status (SES).

Data provided very little support for the social contact theory, which has not been faring well in much recent research. Extent of prior interaction with the various ethnic groups was not related

to respondents' evaluations or distance preferences. Perceived cultural dissimilarity and perceived SES differences, however, were strongly predictive of preferred social distance across all possible social activities. Since SES and cultural dissimilarity are so highly correlated in Holland, as elsewhere, it was impossible to disentangle the economic from the cultural differences explanations of the observed ethnic hierarchical differentiation. However, the extent to which the respondents judged the outsiders as culturally deviant was associated with the absolute amount of social distance desired. A final interesting finding presented in Hagendoorn's research concerns the relationship between evaluation of one's own group (in this case, the Dutch) and other ethnic groups. As predicted on the basis of the theories of Sumner (1906; also see Levine & Campbell, 1972) and Tajfel (1974), the more positive respondents' evaluation of the in-group, the more negative was their evaluation of out-groups (and hence, the greater the preferred social distance).

Self/Other Image. A study that addressed some of the same issues discussed in Hagendoorn's research was presented by Kay, Curtis, and Brown (Wilfrid Laurier University, Canada), who performed a secondary analysis of data from the 1984 Canadian National Election Study, which involved intensive in-person interviews of 3380 respondents. Emphasis in this research was placed on the particular image that various linguistic, ethnic, and religious groupings held of themselves, and the extent to which this self-perception corresponded with that of the other groups. For reasons of cost, the social psychological detail evident in the Dutch survey could not be matched in the Canadian national survey; however, in broad strokes, the Canadian research compliments that of the Dutch.

Not surprisingly, Kay et al. found that groups' self-ratings were invariably and significantly more positive than ratings they received from other groups. This result held for almost all of the various elements of the survey: French speaking, English speaking, whites, Jews, and members of the women's movement. The one exception to this finding was the self-ratings of "nonwhites;" however, this group consisted of only 88 respondents of widely varying socio-demographic characteristics, and as such, these data must be interpreted with caution. Consistent with Hagendoorn's research, there is evidence in the data which suggests that the more positively one evaluates one's own group, the more negatively other (outsider) groups are evaluated. In addition, the data support the conclu-

sion that economic dissatisfaction and lack of education are both associated with higher levels of ethnocentrism. Research reported by Scheepers (University of Nijmegen, the Netherlands) corroborated these results in a Dutch national sample of 1800 respondents. Reflecting back to Hagendoorn's research (in which high school and college students served as respondents), this latter finding of Kay et al. suggests the possibility that the Dutch students' negative evaluation of lower SES, culturally distinct subgroups might in fact represent a reaction to the attitudes and behaviors expressed toward them by the "outsider" groups.

Attitudes and Actions Toward Deployment of Nuclear Weapons. In an ambitious project organized by H.J.C. Rebel (Dutch Ministry of Defense), a consortium of psychologists, pollsters, and political scientists discussed research on a structural equation model which employed measures of past voting behavior, pacifistic attitudes, and militaristic attitudes to predict attitudes toward NATO, nuclear weapons in general, East-West antagonisms, perception of the enemy (in this case, the USSR), the war-preventing role of nuclear weapons, the deployment of nuclear weapons in the Netherlands, and the respondent's action experience (previous actions opposing or favoring nuclear weapons) and action intentions. Panel data on 487 respondents were collected in 1984 and 1985. Discussants provided details of the means by which measurement scales were developed and validated, and developed the theory that formed the basis of their predictive equations.

The model proved reasonably successful in predicting attitudes toward the deployment of nuclear weapons. A total of 55 percent of the variance was accounted for by the direct effects of general attitudes toward nuclear weapons, pacifism, the war-preventing nature of nuclear weapons, and respondents' voting behavior. (Pacifism was by far the most powerful predictor in the structural equation model.) Attitudes toward deployment of nuclear weapons, in turn, influenced respondents' intentions to act for or against deployment. The variables that measured enemy image and respondents' perceptions of East-West antagonisms did not add to the predictive capabilities of the model. The discussants noted that although the research was preliminary, the results provided some indications of the likelihood of success of various tactics that might be used to influence mass opinion regarding the deployment of nuclear weapons.

Symbolic Politics. In an interesting presentation, David Sears (University of California, Los Angeles) discussed a



theoretical development that has the potential to integrate much of the research discussed to this point. Sears observed that past theories of social action typically are couched in terms of actors' self-interest. This economic-man approach appears eminently sensible, but it might not correspond with the ways in which people actually operate in situations involving highly valenced beliefs. As an addendum to the classic approach, Sears suggests the concept of "symbolic politics," which represent one's affective attachment to political symbols, irrespective of the implications for self-interest of these symbols. Thus, a mother might oppose busing of school children because she does not wish to have her child attend school miles away from home. The mother's childless next-door neighbor might oppose busing not because of the practical difficulties involved, but because she does not approve of children of different races attending the same schools, socializing, etc. The ultimate attitude toward busing appears the same in both cases, but the underlying foundations of the attitudes are quite different. As such, tactics that might successfully mediate one attitude would probably have very little influence on the other.

Sears proposes that the self-interest and symbolic politics aspects of political attitudes are orthogonal; as such, knowledge of the different levels of each of these components of political attitudes is necessary if one is to develop a successful theory of influence. In his own work on school integration, Sears has found that symbolism plays a very powerful role in people's attitudes.

#### Applications

The Dutch Peace Movement. One of the most interesting of the nonresearch symposia was presented by a panel of activists from the Dutch Peace Movement (DPM). The DPM, which began its life in the late 1970's, was an attempt on the part of a heterogeneous assortment of citizen groups to persuade the Dutch government not to deploy cruise missiles in Holland. In response to this plan, the DPM mobilized a nationwide petition campaign. Nearly 33 percent of the electorate (3.75 million people) signed the petition. Of the nonsigners, only 20 percent favored deployment, while 70 percent of the signers were unconditionally opposed. This was the largest movement in Dutch politics in terms of numbers of signers, the level of activism attained, the amount of public discussion stimulated, etc. For example, nearly 40 percent of the electorate (signers and nonsigners

alike) took part in public discussions about deployment. Despite the active involvement of the church, labor unions, and nearly all of the center and left-wing political parties, the government rejected the petition and voted to deploy the missile.

In response to the government's action, the DPM collapsed.

The state of disorganization of the DPM was clearly evident in the conflicting interpretations and predictions of the panelists. Age was strongly (and negatively) associated with degree of negativism with the defeat. The younger panelists appeared to have been caught completely off guard by the government's action, and had come to the conclusion that the movement had failed. The older, more experienced, and perhaps wiser, panelists attempted to come to grips with the problem, and to propose interpretations that were not as bleak. Even these individuals, however, did not appear to hold much hope for the future of the movement. The leaders of the movement appeared to have no idea whatever of possible future directions. They clearly had been surprised by the government's response, and had no plan in hand for such a contingency.

Many old-line anti-Vietnam activists in the audience were perplexed by the lack of foresight shown by the Dutch. One remarked that the antiwar movement in the US lost every battle until the US quit the war. He could not understand why the DPM was willing to throw in the towel after losing one "minor skirmish."

While the lack of forward planning of the DPM is indeed perplexing from the perspective of those who lived through the 1960's in the US, the problems confronting the movement are not simple. It is arguable that in the face of a governmental nonresponse, the very essence of the movement contained within itself the seeds of its own destruction. Consider the following difficulties. DPM leadership wanted to mobilize as much of the population as possible. In this way, it hoped to influence members of the government, whose reelection contests came close on the heels of the presentation of the petition. The plan to attract a mass audience dictated that the actions required of the citizenry be minimal. Hence the petition, which some argued resulted in a negative, or nonactive perception on the part of the rank and file of the movement--"Sign it and forget it, there's nothing more to do." To gain the widest possible representation, labor unions and the church were solicited, and proved cooperative. However, these organizations were somewhat suspicious of one another, thus precluding truly constructive and

cooperative work. Given the nature of the signers, it is unlikely that an escalation of the stakes was feasible. The typical middle class petition signer was not likely to take to the streets, even at the urging of the head of the movement. And, in the face of all of this, despite its rejection of the petition, the government was reelected. These complexities in large part account for the puzzlement of the DPM leadership over future directions of the movement.

If ever there was a need for a graphic demonstration of the importance of research and theory, however, the collapse of the DPM provides it. The leaders of the movement appeared completely uninformed of any of the mountain of literature on organizational development, bargaining, negotiation, mass communication and persuasion, etc. or, if informed about these literatures, unable to put the implications of the research into practice. While it is difficult to criticize a Dutch citizen, even a full-time political activist, for not having read Alinski, it is incomprehensible that he would not have learned the lesson of Pyrrhus, whose victory was attained at such a cost that a war was lost.

Psychology and Negotiation of the Israeli-Palestinian Conflict. The presidential address was given by Herbert Kelman (Harvard University), who has long worked with Arab and Israeli citizens (governmental and nongovernmental) in an attempt to apply psychological principles to enhance the outcome of the negotiation process. Kelman's major thrust is that the Palestinian issue has been viewed by the combatants as a zero sum conflict, where one's gains are bought at expense of the other. Under such circumstances, negotiation cannot succeed, since recognition of the other's rights (say, to the West Bank) represents a negation or abandonment of one's own rights.

Kelman has attempted to shift the perception of the conflict to one in which the correlation between one side's gains and the other's losses is not perfect. He stresses the importance of mutual recognition, facilitated through a prenegotiation process that serves to destroy the monolithic view of the "enemy," and to foster a differentiation between the other's symbolic ideology (see Sears' work, discussed earlier) and their operational program. Kelman's approach is laudable, and well-grounded in replicated empirical research. Its chances for success, however, appear minuscule if the reactions of his copanelists are any indication of the typical response to his suggestions.

In a departure from the traditional presidential address, Kelman asked Morde-

chai Bar-On of the Israeli Knesset and Edward Said (Columbia University) to address his ideas from the Israeli and Palestinian perspectives. Bar-On is founder of a movement in Israel to return captured lands to the Arabs, even to the extent of opening Jerusalem to all, in hopes of attaining peace in the region. The size of Bar-On's movement is difficult to gauge; if his claims were valid, arabic rather than hebrew would be the principal language of the Old City. Said's credentials also are difficult to evaluate; he has served as spokesman for the Palestinian cause on numerous occasions. Who or how many he represents is unclear. What is clear, however, is that the two spokesmen had little to say to one another; Bar-On seemed intent on pursuing a policy that could succeed only in bringing down any Israeli government that backed it, while Said was insistent that all blame for all troubles be placed at the feet of the Israelis, and until they recognized this, nothing could ever be accomplished. If Kelman is right, the prognosis for a peaceful solution in the region is even bleaker than most analysts imagine.

A telling picture of the difficulties to be overcome in solving the Israeli-Palestinian conflict was provided unwittingly by Kelman's invited discussants. Despite the fact that they were separated at the podium by no more than 2 feet, not once during the 2-hour session did Bar-On and Said even glance in the other's direction. If a picture is worth a thousand words, this one was worth a million.

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8/13/86

## Biological Sciences

### SECOND INTERNATIONAL WORKSHOP ON NEUROIMMUNOMODULATION

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1987 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

#### Introduction

The Second International Workshop on Neuroimmunomodulation was held at the Hotel Libertas in Dubrovnik, Yugoslavia, from 1 through 6 June. About 150 scientists, including speakers, attended this focused and intensive workshop on the interrelationships between the nervous and immune systems. The participants were from 23 countries, attesting to the worldwide interest in the subject of neuroimmunomodulation.

The scientific program consisted of 10 sessions with invited speakers as well as short, oral presentations and poster sessions. The scientific sessions covered a wide range of topics including neuroendocrine effects, neuroendocrine receptors, pharmacological and neurophysiological aspects, stress, and behavior, as well as psychiatric and neurological disorders with immunological features. A detailed account of this workshop is presented in ONRL report C-7-86. The proceedings of this workshop, expected to be available in early 1987, will be published in full by the New York Academy of Sciences.

The following sections summarize some of the extensive number and range of presentations dealing with this relatively new and important area of research, namely, the interactive mechanisms relating the central nervous system and the immune system. The application of research on neuroimmunomodulation to the clinical area has tremendous potential.

### Neuroendocrine Correlates of Neuroimmunomodulation

J.W. Hadden (Immunopharmacology Program, University of South Florida Medical College, Tampa) presented a review of the mechanisms by which lymphocytes "sense" their environments as well as discussing his own research in this area. In summary, it appears that lymphocytes are exposed *in vivo* to a variety of environmental and humoral influences including neurotransmitters, hormones, and inflammatory mediators which modulate their functions in response to immunologically specific antigenic stimuli. It seems that in one way or another, the mechanisms of hormone action (i.e., the cyclic nucleotides, membrane ATPases, nuclear processes, and calcium influx) are involved in the expression of many of the nonspecific and the specific stimuli. In general, lymphocyte functions appear to be modulated in a positive way by cyclic GMP-related mechanisms and in a negative way by cyclic AMP. Recent evidence indicates that the regulation of T-cell ontogeny involves a series of thymic epithelial products (including thymic hormones) and of interleukins. Humoral and neurogenic influences derived from the central nervous system are far more critical than previously suspected in the maintenance and regulation of *in vivo* immune responses.

G.J.M. Maestroni, A. Conti, and W. Pierpaoli (Istituto Cantonale di Patologia, Locarno, Switzerland, and Institute for Integrative Biomedical Research, Ebmingen, Switzerland) presented data pointing to a primary immunomodulatory role for the pineal gland and suggested that their findings offer the basis for developing new, interesting, and physiological immunotherapeutic interventions.

A. del Rey, H. Besedovsky, E. Sorokin, and C. Dinarello (Swiss Institute for Medical Research, Davos, Switzerland) reported on their studies on the immunoregulatory feedback between interleukin-1 (IL-1) and glucocorticoid hormones and discussed the postulated significance of their findings. They reported on a reciprocal situation in which IL-1 stimulates adrenocorticotrophic hormone (ACTH) and glucocorticoid release *in vivo*. Their results strongly suggest that an IL-1 mediated glucocorticoid increase constitutes part of a normal host response to environmental antigenic stimuli. Del Rey et al. suggested that glucocorticoid immunoregulatory mechanisms may exert a continuous surveillance of immunological cell mass and activity, and thereby prevent an excessive cumulative expansion of immunological cells that could then favor autoimmune and lymphoproliferative diseases.

Using molecular biological techniques, H.J. Westly (Department of Animal Science, University of Illinois, Urbana) reported on the identification of pro-opiomelanocortin (POMC) messenger RNA (mRNA) in Newcastle disease virus-infected murine splenocytes. He showed that virus-infected splenocytes express mRNA that codes for the synthesis of POMC and that this large precursor molecule is probably the source of splenocyte-derived ACTH and  $\beta$ -endorphin. His data provided direct evidence that splenocytes can be activated to synthesize pituitary-like hormones.

A.V. Schally (VA Medical Center and Tulane University School of Medicine, New Orleans, Louisiana) presented a very detailed and exciting talk on the treatment of hormone-dependent cancers with analogs of hypothalamic hormones. His new approach to the treatment of endocrine-dependent or hormone-sensitive tumors based on agonists of luteinizing hormone-releasing hormone (LH-RH) or somatostatin analogs appears to be promising. Schally thinks that methods based on the use of LH-RH analogs and somatostatin analogs might supplement, or in some cases, replace conventional procedures for the treatment of hormone-sensitive cancer.

#### Enkephalins-Endorphins: Immunomodulators

J. Wybran and L. Schandené, (Department of Immunology and Haematology, Erasme Hospital, Free University of Brussels, Belgium) reported on their very interesting studies, *in vitro* and *in vivo*, upon the effects of methionine-enkephalin (Met-Enk) upon the human immune system. Their results indicated that Met-Enk, an endogenous (natural) opioid substance acting mainly on the nervous system, stimulated cell-mediated immunity both *in vitro* and *in vivo* and as such may be used as an immunorestorative agent. Furthermore, Met-Enk is likely to play a physiological role in the relations existing between the immune, the endocrine, and the nervous system. Met-Enk was administered *in vivo* without any toxic side effects for 2 to 6 weeks to pre-AIDS and AIDS patients in order to assess the immune effects. The results showed that Met-Enk stimulates cell-mediated immunity *in vivo* and has immune-enhancing properties.

A study on opiate-induced suppression of antibody (A6) production *in vivo* in mice was presented by R.J. Weber, A. Pert, K.C. Rice, and A.A. Hagan (National Institute of Mental Health, Bethesda, Maryland). These researchers investigated the effects of opiates on the *in vivo* A6 response to T-dependent and T-independent antigens. Their find-

ings indicated that endogenous opiates may be important neuroendocrine modulators of immune responses *in vivo*. They found that chronic morphine administration effected a relatively early event in the generation of an A6 response *in vivo* and that the morphine-induced immunosuppression was relatively T-dependent.

G.D. Jankovic and D. Maric (Immunology Research Center, Belgrade, Yugoslavia) reported on experiments designed to examine the immunomodulating activities of enkephalins (Met-Enk and Leu-Enk) in mice and rats. Their results indicated that enkephalins are potent immunomodulators in mice and rats. They found that immune responses were suppressed in all groups of mice treated with both enkephalins, although in rats, Met-Enk was more immunosuppressive than Leu-Enk.

In addition to the above study on humoral immune response, Jankovic and Maric also examined the effect of Met-Enk and Leu-Enk on cell-mediated immune reactions in rats. Their results demonstrated a depressed cell-mediated immune responsiveness in rats treated with enkephalins. This study of cellular immunity also indicated that enkephalins are important regulators of immune mechanisms *in vivo*, as did the previous study of humoral immunity.

The immunologic effect of Met-Enk was also studied by J. Chapman (Travenol Laboratories, Round Lake, Illinois). He used a battery of immunological tests of humoral and cell-mediated immunity to investigate the effect of Met-Enk on immune function. Met-Enk was found to have, for example, a protective effect in mice infected with *Streptococcus pneumoniae* and *Listeria monocytogenes*. Other *in vivo* as well as *in vitro* studies showed that Met-Enk could stimulate immune function and that its immunologic effects may be mediated through a ligand-receptor interaction.

R.E. Faith and N.P. Plotnikoff (University of Houston, Texas, and Oral Roberts University School of Medicine, Tulsa, Oklahoma) also obtained evidence of immune modulation by Met-Enk. Their results showed that host resistance to viral (4SU-2) infection and inhibiting of local subcutaneous tumor growth of B16-BL6 melanoma in mice was significantly enhanced by administration of Met-Enk. Also, increases in NK activity of splenic lymphocytes were obtained following injection of Met-Enk.

S. Amir (Department of Isotope Research, The Weizmann Institute of Science, Rehovot, Israel) provided new evidence that endogenous opiates play a central role in the pathogenesis of fatal anaphylactic shock. Amir presented evidence indicating that opiate antagonists,

including those with receptor-level actions such as naloxone and naltrexone and compounds such as thyrotropin-releasing hormone (TRH) may have significant therapeutic value in the treatment of anaphylactic shock.

Further evidence in support of a regulatory interaction between the immune and neuroendocrine systems operating through common signal molecules and receptors was presented by E.M. Smith (Department of Microbiology, University of Texas Medical Branch, Galveston). Smith and coworkers used the B-lymphocyte mitogen, bacterial lipopolysaccharide (LPS), to induce fractionated mouse splenocytes to synthesize opiate-related peptides in order to identify the major population of endorphin-producing cells. Smith et al. found the LPS-induced endorphin bound to delta-type opiate receptors. Their results also indicated that endogenous opiate induced during endotoxic shock may originate from B-lymphocytes and macrophages.

C.J. Heijnen and P.E. Ballieux (Departments of Pediatric Immunology and Clinical Immunology, University Hospital, Utrecht, The Netherlands) presented their research which was designed to investigate the influence of endorphins on lymphocyte function. Their results showed that endorphins did indeed modulate the generation of the antibody response and that they can also influence the fluidity of lymphocyte membranes (i.e., cellular mechanisms). The latter effect may have functional consequences for the expression of various functionally important receptors on the cell surface leading to an altered immune response. The studies were carried out using human peripheral blood B cells in *in vitro* experiments.

#### Neuroendocrine Receptors in the Immune System

E.M. Smith (University of Texas) presented an excellent overview of his research as well as that of others on a molecular basis for interactions between the immune and neuroendocrine systems.

The following summary emphasizes the main points discussed by Smith. Leucocytes stimulated with endotoxin and viruses or with the hypothalamic-releasing hormone, corticotropin-releasing factor synthesize the POMC neural peptides, ACTH, and endorphins. Thus, the POMC gene appears not only to be expressed and processed by cells of the immune systems but is also controlled by brain and adrenal hormones in a fashion analogous to that observed in the pituitary gland. It appears that leukocytes produce and are acted upon by neuroendocrine peptide hormones. Such findings suggest a complete regulatory circuit between the immune and

neuroendocrine systems which operates through a common set of peptide hormones and their receptors.

C.J. Wiederman and C.B. Pert (Section on Brain Biochemistry, National Institute of Mental Health, Bethesda, Maryland) reported on their studies to investigate the presence of neuropeptide receptors on cells in lymphatic tissues. This work was particularly interesting since these investigators used autoradiographic visualization of neuropeptides. They found that certain neuropeptides, including substance P, somatostatin, cholecystokinin, and vasopressin bound specifically to morphologically defined spleen areas that are known to represent the presence of different cell types (i.e., periarteriolar sheet, germinal center, marginal zone, red pulp).

H. Ovadia, I. Lubetzki-Korn, and O. Abramsky (Department of Neurology, Hadassah University Hospital, Jerusalem, Israel) reported on a study to specify and characterize dopamine-binding sites on isolated membranes of rat thymocytes. Their interesting results showed that although thymocytes do contain dopaminergic sites, it appears that these sites have higher affinity to the catechol portion of the molecule. Furthermore, the binding site did not seem to express the same stereospecificity found in dopaminergic neurons in the central nervous system.

#### Natural Mediators and Pharmacology of Neuroimmunomodulation

A detailed study on the regulation of lymphocyte and mast cell function by peptides of the sensory nervous system was presented by D.G. Payan and E.J. Goetzel (Howard Hughes Medical Institute and Department of Medicine and Microbiology, University of California Medical Center, San Francisco). Their results showed that neuropeptides and immunologically derived neuropeptide-like factors appear to mediate bidirectional communication between the nervous and immune systems that can be critical for optional host defenses and expression of hypersensitivity.

S.M. McCann (Department of Physiology, University of Texas Health Science Center, Dallas) reviewed the subject of hypothalamic control of pituitary hormones involved in neuroimmunomodulation as well as presenting studies by his group. Essentially, it appears that in response to stress, there is a complex interaction of peptides intrahypothalamically. Corticotropin-releasing factor (CRF) augments its own release by an ultra-short-loop positive feedback. There is a negative ultra-short-loop feedback of growth hormone-releasing factors and

somatostatin. Vasopressin appears to augment the CRF release as well as to act directly on the pituitary, and there are complex interactions of various peptides to influence prolactin and growth hormone release.

*In vitro* studies of immunoregulation by substance P (SP) and somatostatin (SOM) were presented by A.M. Stanis, R. Scicchitano, D. Payan, and J. Bienenstock (Intestinal Disease Research Unit and Department of Pathology, McMaster University, Hamilton, Ontario, Canada, and Department of Medicine, University of California, San Francisco). Their results suggest the possibility of cell-cycle-dependent mechanisms for these neuropeptides and that (in agreement with other presentations at this workshop) they play a role in immunoregulation.

M. Pawlikowski and A.V. Schally (School of Medicine, Lodz, Poland, and Veterans Administration Medical Center, New Orleans, Louisiana) provided additional evidence of an immunomodulatory action of SOM. They studied the influence of SOM 1-14 on the spontaneous proliferation of mouse splenocytes and on the inhibition of human leukocyte migration.

#### Neurophysiological Correlates of Neuroimmunomodulation

K. Bulloch (School of Medicine, State University of New York, Stony Brook) gave an excellent presentation of her important and interesting studies on the role of nerve-related acetylcholinesterase (AChE) in the development and function of the thymus gland. Bulloch found that AChE-positive nerves were involved in the maturation of thymic tissue. In studying the innervation of the postnatal thymus, she found that AChE-positive nerves were involved in steroid-induced mechanisms of regulating thymocyte populations.

D. Saphier, O. Abramsky, S. Feldman, G. Mor, and H. Ovadia (Department of Neurology, Hadassah University Hospital) used chronically implanted electrodes in male rats to examine possible neurophysiological changes during the course of the immune response to the intraperitoneal injection of sheep red blood cells (SRBC). They recorded daily changes in the preoptic areas (POA) and hypothalamic paraventricular nucleus (PVN) multiunit activity (MUA). Male rats bearing chronically implanted recording electrodes showed increases of up to 300 per cent in POA MUA on day 5 following SRBC immunization, with significant decreases being recorded on days 3 and 8. PVN MUA, recorded from the site of CRF synthesizing cells, revealed significant increases on day 6 after the injection. These results

appear to correlate with the course of antibody production during the immune response and with concomitant elevations of corticosterone levels, secretion of which is controlled by hypothalamic CRF.

M. Katayama and M.M. Yokoyama (Departments of Neurosurgery and Immunology, Kurume University, School of Medicine, Kurume, Japan) reported on a study designed to analyze the effects of hypothalamic lesions in mice on lymphocyte subsets in order to better understand the roles of the central nervous system (CNS) in the immune response. The results of this detailed study showed that hypothalamus contains at least two regions influencing the host's immune response. These two regions, the anterior and posterior parts of the hypothalamus, seem to play a role in the immune modulation of both helper and suppressor T-lymphocytes. The remaining middle part of the hypothalamus appears to play a role of control mechanism in the immune regulation to T and B lymphocytes.

B. Radosevic-Stasic, L. Polic, and D. Rukavina (Departments of Physiology and Immunology, Medical Faculty, Rijeka, Yugoslavia) investigated the antibody and cell-dependent immunity of rats sensitized at different times of the day and the consequences of the blockade of the sympathetic nervous system on these events. Their results point to the existence of circadian rhythms in immune functions and to the role of the sympathetic nervous system in their formation.

J.W. Karazewski and J.M. Krueger (Department of Physiology, University of Tennessee, Memphis) reported on studies to ascertain if muramyl peptides (MPs) might play a role as mammalian physiological modulators. These peptides have been implicated in several mammalian biological processes, including immune responses and temperature and sleep regulation. However, there are no known mammalian synthetic pathways for components of MPs such as muramic acids and diamino-pimelic acid. In a detailed study, these investigators found that MPs were present in normal mammalian and CNS processes, and that transport systems existed to allow and control entry of MPs into brain from blood. These results indicate that MPs are integrated into normal mammalian physiological processes.

#### Stress and Immunity

B.H. Fox (Boston University School of Medicine, Massachusetts) presented preliminary data from a long-term cooperative study designed to investigate the relationships between behavioral type and cancer mortality. The preliminary study was carried out on a cohort of 3154 men relating personality patterns to



age-adjusted cancer mortality. Type A personalities (driving, impatient, sometimes hostile) go through states of reported frustrations because of unachieved goals. Thus, they are alternately able to cope and unable to cope. Such a pattern would theoretically tend toward repeated episodes of suppression and recovery of both the immune system (IS) and the DNA-repair system (DNA-rs) with associated increased probability of cancer appearance (DNA-rs suppression) or growth of transformed cells (IS suppression). The type A personality was found in this preliminary study to have a significantly higher risk of cancer mortality than other personality types.

H.K. Fischman, D. Kelly, and R. Pero (New York State Psychiatric Institute, New York) studied the effect on DNA when rats were exposed to various forms of stress with different degrees of severity. The results showed that all the stressors increased sister chromatid exchanges, although to differing degrees, and that the level of unscheduled DNA synthesis measured in leukocytes was twice as high in stressed rats as compared to controls. Their hypothesis, supported by their data, is that psychogenic stress may trigger pathology by altering DNA.

G. Croiset, R.E. Ballieux, D. de Wied, and C.J. Heijnen (Rudolph Magnus Institute for Pharmacology; and the Department of Clinical Immunology, University Hospital, Utrecht, The Netherlands) investigated the influence of a short and mild form of emotional stress induced by the passive avoidance procedure on the reactivity of the immune system of rats. T and B cell mitogen responsiveness as well as the capacity to generate a primary antibody response *in vitro* were tested. The results demonstrated that subjection of rats to this conflict situation resulted in a decrease in immune reactivity.

D. Pericic and M. Poljak-Blazi (Department of Experimental Biology and Medicine, Rudjer Boskovic Institute, Zagreb, Yugoslavia) reported on a study with the aim of finding out whether and how diazepam, a widely used anxiolytic drug, affects the immune system of stressed rats. Their results showed that only higher doses (10 mg/kg body weight) of diazepam induced immunosuppression. This did not correlate either with the metabolism of GABA and 5-hydroxytryptamine or with the levels of brain noradrenaline and dopamine but did correlate with the diazepam-induced enhanced secretion of glucocorticoids.

H. Teshima, H. Sogawa, H. Kihara, S. Nagata, and Y. Ayo (University of Kyushu, Fukuoka, Japan) reported on a study of

the influence of stress in the population of T cell subsets in the blood, thymus, and spleen of stressed mice using flow cytometry and monoclonal antibodies to measure the subsets. Their results showed that stress influenced the immune system via the CNS since changes caused by stress could be prevented by pretreatment using diazepam.

#### Behavior Associative Learning and Immunity

R. Ader (University of Rochester Medical Center, Rochester, New York) presented an excellent review of the subject of behavioral modulation of immunity including his own research as well as that of other groups. It appears that behavioral factors, including the experimental history of the organism, current social and environmental conditions, and so-called "stress" are capable of influencing the immune system as evidenced by the exacerbation of immunologically mediated disease states and by the direct measurement of various parameters of immune function. Involvement of the CNS in the modulation of immunity is most dramatically illustrated by the classically conditioned alteration of immune responses. Ader et al. found that a net enhancement of immunologic reactivity can be conditioned. The biological impact of conditioned changes in immune responses is illustrated by studies in which the onset and treatment of autoimmune disease has been altered by re-exposing conditioned animals to the CS previously paired with an immunoregulatory agent.

N. Cohen, D. Bovbjerg, and R. Ader (Cornell University Medical College, New York, New York, and University of Rochester Medical Center) presented an interesting report on the conditioned enhancement of delayed-type hypersensitivity (DH) in mice using cyclophosphamide (CY), which is best known as an immunosuppressive drug. Cohen et al. and others have shown previously that the immunosuppressive effects of CY could be classically conditioned. They found that the DH responses of conditioned mice could be enhanced significantly. Thus, Cohen et al. have found that, depending on the dose and timing relative to sensitization and challenge, CY with antigens can be immunoenhancing, and this can be classically conditioned.

R.N. Hiramoto and V.K. Ghanta (Departments of Microbiology and Biology, University of Alabama, Birmingham) studied the regulation of natural killer activity (NK) by conditioning, using two types of unconditioned stimuli (US). These US's were poly I:C and CY with saccharin and LiCl as the conditioned stimulus (CS). With the combination of the CS

and poly I:C, the NK response was conditioned in a positive way, whereas the use of CY as the US conditioned the animals' NK response in a suppressive way. Since the duration of conditioning was short, as only one association trial was needed, it will be possible to use this system to study the mechanism of conditioning.

V.J. Djuric and B.D. Jankovic (Institute for Psychology and Immunology Research Center, University of Belgrade, Yugoslavia) presented an intriguing study designed to examine whether anaphylactic shock can be used as an effective US in rats. These animals, as shown in previous studies by this group, learn to associate illness with ingestional stimuli and show taste aversion (TA) to otherwise preferred flavors if it was previously used as a signal for the illness-inducing unconditioned stimulus. The CS used was sodium saccharin. Their results showed that rats can associate gustatory stimulation with anaphylactic shock or its consequences.

#### Cancer, AIDS, and Immunity

N.B. Plotnikoff and J. Wybran (Oral Roberts University and Erasme Hospital, Free University of Brussels, Belgium) presented a very interesting clinical study indicating that Met-Enk may have therapeutic potential as an immunomodulatory agent. This collaborative group studied the immunomodulatory effects of Met-Enk in normal volunteers in a wide range of doses (1 to 250 mg/kg body weight) and found significant increases in all T-cell subsets and lymphocyte proliferation as well as NK cell activity. In cancer patients, including those with AIDS, similar increases in T-cell subsets and lymphocyte proliferation were observed. In addition, significant increases in IL-2 receptor expression and levels were found. Furthermore, increases in IL-2 and  $\gamma$ -interferon as well as activation of macrophages were also observed. Of great interest was the finding that in patients with Kaposi's Sarcoma (AIDS) treated with Met-Enk, the sarcoma lesions were crusting, healing, and diminishing in size. Lymph nodes in the axillary area were palpably smaller. Similar findings were observed in patients with lung cancer receiving infusion of Met-Enk in a dose range of 10 to 25 mg/kg.

R. Peck (Central Research Units, F. Hoffman-LaRoche & Co., Ltd., Basel, Switzerland) reported on studies of a variety of neuropeptides and neurohormones regulating the activities of a key cell of the immune system, the macrophage. Both positive and negative modulation of macrophage effector functions by neuropeptides or neurohormones were

obtained. It is possible that such modulation could contribute to the influence of cognitive stimuli (physical, emotional, chemical) in infection and neoplasia.

#### Psychiatric and Neurological Disorders With Immunological Features

C.A. Williams (State University of New York, Purchase) presented detailed and interesting studies on the neuropharmacology of immune complex activity in the rat hypothalamus. He introduced affinity-purified rabbit antihuman serum albumin via chronic cannula to the perifornical hypothalamus, then measured the effect of food and water intakes following intracranial stimulation by saline, norepinephrine, or carbachol. He found that the responses showed that focal action of serum complement-derived peptides (the anaphylatoxins C3a and C5a) could account for the immune complex effect in his studies. Another presentation at this workshop supports the anaphylatoxin hypothesis by showing that the immune complex response depends on the activation of the complement cascade.

R. Ganguli and R. Kelly (University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania) studied a group of patients with schizophrenia to determine if they had characteristics commonly associated with the presence of autoimmune disease. They found that patients with schizophrenia had evidence for activation of the immune system and displayed immunologic characteristics commonly associated with the presence of an autoimmune disease. The data suggests that there may be a subpopulation of schizophrenic patients who have an autoimmune process directed to the brain.

In another study of patients with schizophrenia, F. Villemain and J.F. Bach (INSERM Unit 25, Hospital Necker, Paris, France) investigated the production of IL-2 (a lymphokine produced by stimulated T-cells) as a reliable parameter of T-cell function. The results obtained showed a significant decrease of IL-2 production by lymphocytes of patients as compared to normal controls, indicating, as above, an immunological abnormality in schizophrenia.

Immune function in schizophrenic patients was also studied by N. Müller and W. Mempel (University of Munich Psychiatric Hospital and University of Munich Medical Hospital III, Munich, West Germany). Suppressor cell function was tested in mitogen systems and in the mixed lymphocyte cultures: T-cell subpopulations were classified with monoclonal antibodies. Similar results were obtained with both assays--i.e., significantly reduced activity of suppressor cells in schizophrenics before and after the



treatment with neuroleptics as compared with a control group of nonschizophrenic psychiatric patients.

#### Conclusion

The workshop on neuroimmunomodulation (i.e., the interrelationship between the central nervous system and the immune system) was an intensive conference covering a wide range of topics being studied and in many instances involved collaborative projects between immunologists, endocrinologists, neurochemists, psychologists, and psychiatrists. Studies included the effects of neuropeptides and neuroendocrine hormones on immune system function, neurophysiological correlates, effects of stress, and behavioral modulation of immunity, as well as clinical studies in which neuropeptides were found to have some effect in cancer and AIDS patients. Immune system abnormalities were reported in patients with schizophrenia.

Research on neuroimmunomodulation has increased tremendously during the past 3 years and will undoubtedly progress even more rapidly from now on.

8/21/86

## Computer Sciences

### ESPRIT UPDATE

*by J.F. Blackburn. Dr. Blackburn is the London representative of the Commerce Department for industrial assessment in computer science and telecommunications.*

#### Background

The European Strategic Program for Research and Development in Information Technology (ESPRIT) was launched by the European Community in February 1984. It resulted from an initiative taken by the EEC Commission and a Round Table of 12 leading European information technology firms in response to growing concern over the European information technology (IT) industry's reduced competitiveness in the world market. (ESN 38-2:69-71 [1984]; ESN 38-5:248-252 [1984].)

The program is to provide the research needed for competitiveness in the IT industry through collaboration among the European IT organizations and to pave the way for European standards.

ESPRIT was initially established as a 5-year program with a budget of 1.5 billion ECU (~\$1.2 billion), half of which was provided by the European community and half by participating organizations, through shared-cost contracts.

The program provides support in five areas of IT:

- Microelectronics, which covers the basic technology for the design, manufacture, and testing of very large scale integration (VLSI) and high-speed circuits.
- Software technology, including theories, methods, and tools necessary to put software on a sound engineering basis.
- Advanced information processing, including advanced computer architectures covering design, storage, peripherals, signal processing, and knowledge engineering.
- Office systems, including computer and communications systems for applications in office environments.
- Computer integrated manufacturing, covering the application of integrated information processing and communication in manufacturing environments.

#### Operations

The work of ESPRIT is based on published work programs. ESPRIT is organized on an annual cycle in which a revised work program is published each year, giving a review of the strategic situation, describing projects underway, and identifying gaps. This is the basis for a call for proposals which sets out detailed project requirements and invites bids to be submitted by a specified deadline.

The Commission, the Round Table, an ESPRIT Advisory Board, and the ESPRIT Management Committee are responsible for the management of ESPRIT. However, the Commission handles day-to-day management including collection of bids, organization of project evaluation, negotiations, placing of contracts, and monitoring of projects.

Participation in ESPRIT is open to companies, academic institutions, and research bodies. Normally each project must include companies from at least two member states. There is no prohibition on the participation of subsidiaries of multinational companies, so long as the research is carried out within the Community by a Community-based organization.

The basic level of support for projects is 50 percent of allowable costs, quite generously defined. Two categories of projects are funded: Type A Projects are aimed at specific, strategic goals with well-defined objectives, requiring substantial resources and large teams.

About 75 percent of ESPRIT funds are reserved for projects of this kind costing 10 million ECU (~\$8 million) or more. Type B Projects are smaller, more speculative research-oriented projects for which the work program only suggests general themes.

Industrial property rights to information generated by a contractor are owned by the contractor. This information must be made available on a royalty-free basis to other contractors in the consortium and also to consortia carrying on complementary work, provided the information is necessary or useful for the execution of the work. The owner of the information is expected to exploit the results of the discovery, but also, each contractor in the main or complementary consortium is entitled to exploit it too, but subject to conditions regarding freedom to disclose and infringement of commercial interests of the owner.

The ESPRIT Information Exchange System is being established to enable participants to exchange information effectively within and between projects. EUROKOM, an electronic mail and conferencing service, is part of this system.

#### Present Status

Over a thousand proposals were generated as a result of the 1984 and 1985 work programs. Only one out of five could be supported. There are now about 200 projects with 450 organizations and involving about 2000 people full time. The financial commitment to 1 July 1986 was 1.37 billion ECU (\$1.1 billion). The commission has published information for each technical area, giving general strategy, a summary of the work, contact point and project partners.

A few examples of ESPRIT projects are:

- Project 97 (advanced algorithms, architectures, and layout techniques for VLSI signal processing) has produced a solution for a particular type of architecture, among several being investigated, which is 10 times more efficient than the present state of the art. The project has also developed a CAD tool which, together with other existing tools, allows the completely automated design of complex integrated-circuit digital filters in less than a week.
- Project 440 (advanced message-passing architecture and description systems) has provided the basis for the development of a product (OMEGA, environment to develop knowledge-based systems) which has been announced on the market by Delphi, a small company that is the main contractor in the project.

- Project 623 (operational control for robot systems integration) has produced a report titled "Design Rules for Robot Integration into Computer Integrated Manufacturing." The project is investigating the problem of the integration of various technologies in CIM systems and will provide results applicable not only to industrial robots but also to material handling equipment.
- Project 232 (compound semiconductor materials and IC's) has already met some of its technology objectives. The success of the project, together with results achieved in other complementary programs by the same consortium (LEP, Plessey, Siemens, Thomson), has led to the realization of GaAs MESFET 256-bit static RAM circuits with access time of 1.5 ns. LEP has also announced the successful operation of a 1-kilobit static RAM with a longer access time (3.4 ns) but very low power dissipation.
- Project 107 (LOKI--logic-oriented approach to knowledge and databases supporting natural user interaction) has developed tools to optimize access to databases, thereby winning the supreme prize at the 1984 European Conference on Artificial Intelligence.
- Project 121 (handling of mixed text/image/voice documents based on a standard office documents architecture) has defined an office document architecture, resulting in recommendations to the European Computer Manufacturers Association (ECMA) and International Standards Organization (ISO) for standardization.
- Project 32 (PCTE--portable common tool environment), aimed at providing a supporting structure for a family of portable tools, has realized the first prototype based on ADA. PCTE will provide a common framework to serve as a basis for the development of tools for the writing of software. Emphasis will be on portability of the developed tools.

Some major technical achievements in state-of-the-art work in microelectronics include:

- A chip using 0.5-micron feature-size circuits and containing 1 million elements. This work was done by Matra-Harris, France and SGS, Italy.
- Bipolar and CMOS circuits on the same chip using over 30 process steps and 20,000 transistors. This was accomplished by Philips, Siemens, and Stuttgart University.
- An ECL bipolar switch has been constructed and operated at 200 picoseconds.

- A compound semiconductor using gallium arsenide has been demonstrated on a 1-kilobit static RAM with 300 nanosecond access time and low power consumption.

Some major achievements in PCTE are that:

- This project is establishing standard interfaces in tool development. EMERAUD, a French program for a common environment for software engineering, has adopted these interfaces.
- A common UNIX 5 interface has been established. It is called "x open."
- The US DOD is discussing a proposed computer-automated support equipment (CASE) vs. PCTE interface.

A mid-term review of ESPRIT was organized by the Commission to advise on the program's progress, taking particular account of the views of participating organizations. The main conclusion is that ESPRIT has been outstandingly successful in nurturing collaboration between European enterprises. Besides the cooperation on ESPRIT projects there have been other cooperative efforts inspired by the example of ESPRIT projects. An example is the collaboration between Plessey, Siemens, Alcatel Thomson, and Italtel on the development of the next generation of digital switches. Another is the cooperation between Philips and Siemens on the development and production of megabit memory chips.

#### Plans for ESPRIT II

During an ESPRIT technical week to be held in late September or early October 1986, plans for ESPRIT II will be further considered. The focus will be on market requirements and a plan to have products on the market by 1992 that will be competitive in the world market. In microelectronics the emphasis will be on application-specific integrated circuits to meet market needs at reduced cost. An objective in information processing systems will be to improve by a factor of 10 the price performance of a complete system including hardware and software. In applications, emphasis will be on factory automation and office systems with an effort to establish common subsystems.

A task force held a series of workshops and consultations in February which has resulted in an outline package recommended by the Commission for a second phase roughly three times the size of the current program--equivalent to 30,000 man years of work.

The proposal suggests three technical work areas:

1. Microelectronics and peripherals. This requires restructuring of existing activity to include basic hardware

and peripherals. The objective is to provide the Community IT industry with full system capability through access to up-to-date functional components and subsystems based on state-of-the-art solid-state (especially semiconductor) technology. The effort should be divided between silicon technology, compound semiconductors, computer-aided design, and peripherals.

2. Information processing systems. This involves integration of existing AI processing and software areas to reflect the increasing convergence of the work. The objective is to provide capability of producing systems of similar complexity to those produced now with 10 percent resources, and of producing highly complex systems. Emphasis will be on the systems approach, and the effort will be divided between system design, knowledge architecture, knowledge engineering, signal processing, and technology integration projects across all areas.

3. Integration of IT into application systems. This will include the development of existing office systems and computer-integrated manufacturing. The objective is to enhance European capabilities in the integration of IT into systems for use in a broad range of applications. The effort will be divided between:

- Generic technologies and methods in which R&D for technologies, tools, and subsystems can be used in a broad range of applications.
- Factory automation to support the competitive position of European manufacturers through flexible, reliable automated systems of production and to stimulate and increase participation by vendors.
- Office and integration information systems R&D for wide application, and with emphasis on human-activity support systems.

#### Comments

The ESPRIT program has just moved into the second half of its 5-year first phase. It is too early to assess its success overall. However, as confirmed during its mid-term review last fall it has made substantial progress in some areas. In particular, the work in microelectronics is impressive. The demonstration of 0.5-micron feature-size circuits containing a million elements is certainly state of the art. Also, its effect on collaboration among European companies from different countries will have substantial impact on the future of this industry in Europe.

The plans outlined for ESPRIT II with emphasis on products and applications will make it competitive with

EUREKA (ESN 39-12:570-574). One can then ask why both programs. Of course, EUREKA covers a wide spectrum of industries and the whole of Western Europe as contrasted with ESPRIT, which only covers information technology in the EEC countries. ESPRIT is also more centrally coordinated than EUREKA appears to be. Nonetheless the question of overlap in the information technology area is bound to rise.

8/15/86

#### THE SECOND ALVEY CONFERENCE 30 JUNE-4 JULY

by J.F. Blackburn.

##### Introduction

To provide a complete review of the Alvey Program, a 4-day meeting was held at the University of Sussex. It was attended by 530 delegates, mainly from the UK. The first review was held at the University of Edinburgh in June 1985.

The 5-year program has 2 more years to run, but some of the early projects are nearing completion and there is some concern about what is to follow the present program. The IT 86 Committee, headed by Sir Austin Bide, is expected to make recommendations on a successor to Alvey.

##### The Government Overview

Mr. Geoffrey Pattie, minister for information technology, attended the entire first day of the conference and was the first speaker after introductory remarks by Sir Robert Telford, Conference Chairman. In the course of his remarks Pattie assured the audience that the government would act on the recommendations of the Bide committee by the end of 1986. He also said there would be no discontinuity in information technology research.

Pattie spoke of the coming together of many specialists from companies and universities and of the value of the 1985 conference. However he said the time had come to speak of the technical achievements of the Alvey Program. He cited the delivery of the Alice system to Imperial College, London, in June 1986 as an example.

He cited the need for demonstrating the future shape of European collaboration making reference to the EUREKA Conference which immediately preceded the Alvey Conference. He emphasized the growing momentum of advanced civil technology in European planning and gave the pending proposals for ESPRIT II and Race as

further examples of the momentum toward European collaboration.

Pattie said that Europe's and the UK's survival in international markets depends on the successful collaboration of universities and industry. He added that the extent of the present collaboration was unprecedented in peace time.

The three main questions to be answered concerning work in the near future are: the scope of work, the balance between international and national research, and financial support. Government alone, he said, is not the key to success. He referred to his comments made in 1985 that it was not clear that the Alvey Program should continue in its present form beyond the first 5 years. He had said that maybe both Alvey and ESPRIT would have fulfilled their roles during their first 5 years.

Pattie then seemed to qualify and modify his position of last year. He said that those in the collaborative programs should not get into the habit of indefinite continuation of programs; they need a clear picture of the program's relative strengths and weaknesses. There should be no predetermined decision about continuation. However, he then said, international research is no substitute for national research. National research is needed to put the UK in a strong position when participating in international research. He said there is now a need to bring discoveries through to marketable products. The vital role of information technology has been brought to the forefront. The present conference will help to make the choice as to what research is needed to maintain the place of the UK in world competition.

##### The Program Overview

Mr. Brian Oakley, Alvey Program Director, gave an overview of the program progress to date.

The program was launched in May 1983 and now includes 187 full industrial projects, projects involving both companies and universities. It also includes 116 academic-only projects. These latter take only 6 percent of the public funds allocated to the Alvey Program.

The committed public funds to full industrial projects are broken into: Very Large-Scale Integration (VLSI), £61.6 million (£1=£1.50); Software Engineering, £28.3 million; Intelligent Knowledge-Based Systems (IKBS), £33.9 million; and Man-Machine Interface, £27.2 million. Funds committed to communications amount to £4.5 million and to large demonstrator projects, £25.3 million. This gives a total of £180.8 million committed to the 187 full industrial projects. In addition, the 116 academic

projects account for a total of £10.9 million.

Oakley believes that more effort should have been put into computer aided design with user input at the expense of VLSI. More effort should have been devoted to software engineering, he said. One of the largest EUREKA projects of several hundred million pounds is on software engineering.

Various firms have plans to exploit nearly all of the Alvey research work. This is in line with the international programs. Both ESPRIT II and IT '86 will emphasize applications. There will be more application pull than technology push. More than half of the EUREKA projects are in the information technology field. These projects needed Alvey and ESPRIT on which to build.

To summarize the remainder of Oakley's overview, he said that there are more partners per project in VLSI and the least number per project in IKBS. The Alvey Program has led more universities to collaborate with British industry and to less collaboration with the Japanese. The dominant universities in the Alvey Program are Imperial College, Edinburgh, Cambridge, and Manchester. And finally, there are now 2200 professionals working in the program and the peak will be reached at the end of 1986.

Following Oakley's speech were several key presentations which fairly summarize the Alvey Program at this time. I will cover those presentations, speaker by speaker, in the sections below.

#### R.J. Morland, Director, VLSI

The strategy of the program is to achieve 1-micron feature-size silicon circuits concentrating on CMOS and bipolar technologies. The intermediate objective of 1.5-micron technology is near achievement and the plan is now to have 1-micron VLSI technologies ready for transfer to production by 1989.

A unified approach has been adopted in which, in addition to whole processes, there are projects in 14 topic areas associated with the fabrication of microchips. Other projects supply data and analytical understanding in layer-processing and whole-process areas. A project, VLSI 027, is concerned with characterizing and evaluating materials and device parameters for forming various types of silicon-on-insulator substrates for future VLSI circuits.

The basic 1.25-micron bulk CMOS process under VLSI 071 has been successfully exercised in initial test structures. Full characterization of circuits and a pathfinder chip are due in late 1986. An intermediate 2-micron variant has been transferred to pilot production, and the

fully documented 1.25-micron process, including double-level metallization, is scheduled for preproduction in December 1986.

The other bulk CMOS project, VLSI 059, is to develop a 1-micron feature-size process for preproduction in July 1988. An intermediate 1.5-micron process has been successfully used in the fabrication of 4-kilobit static RAM's, and is now completing final optimization of techniques prior to transfer to pilot production in December 1986. Plans for 1-micron pilot production by July 1988 are still on schedule.

Project VLSI 060 has been initiated to establish variants of the bulk CMOS process with characteristics suitable for mixed analog and digital functions as required for telecommunications, speech synthesis, and signal processing. Progress has been made in characterizing bipolar, MOSFET, capacitor and resistor based on the 1.5-micron process at high-voltage operation. The intermediate aim of the project is a 1.5-micron analog process demonstrated by early 1988.

There are also projects to solve the inherent problems in advancing layer processing by the development of a wide range of machines and equipment, of new techniques, and of new materials.

Finally, there are projects dealing with packaging, wafer process automation, and microcircuit testing.

In microlithography, project VLSI 041 is linked to whole processes and extends the use of single-layer resist technology by using the enhanced performance of new photoresist materials. This work is matched by related work in mask making.

Dry etching, project VLSI 006, has made progress on etching of aluminum films alloyed with Si and Cu. Methods for controlling using-edge profiles with sizes down to 1.5 microns are being assessed in pilot line production.

Many aspects of layer processing are mathematically modeled to provide detailed understanding of the effects and to assist in optimizing processing parameters for VLSI applications. Promising physical models have been developed in VLSI 066 for aspects of ion implantation and dopant diffusion.

In VLSI 005 the implantation and diffusion behavior of dopants in silicon, silicon-on-sapphire, amorphous silicon, polycrystalline silicon, and titanium silicide have been extensively characterized.

The CMOS-SOS project VLSI 058 has concentrated on the development within 3 years of a 1.5-micron feature-size technology. A test chip has been made and an initial process sequence and

layout rules have been produced. Transfer of the 1.5-micron process to pilot production is due in late 1987. Transfer of 1-micron feature-size to pilot production is scheduled for mid-1989.

The major bipolar program, VLSI 062, involves the development of a CDI process at 1-micron feature size. Conditions for an intermediate 1.5-micron variant, with double-layer metallization and a grid pitch of 4.5 microns, have been established. A prototype 3250-gate autoroutable array has been demonstrated, and a 40,000-gate array has been designed and is being implemented. Transfer to pilot production is scheduled for mid-1988.

The other bipolar whole-process project, VLSI 061, is to develop a 1-micron ECL bipolar capability for very high-speed analogue and digital operation. The first 1-micron enhanced efficiency polysilicon transistors have been made. Transfer to pilot production is due in March 1989.

#### D.C. Talbot, Director Software Engineering

Two main goals of the software engineering program are:

- Improved quality; i.e., satisfying criteria such as performance, reliability, security, on-schedule delivery, and meeting the needs of the users
- Improved productivity; i.e., reducing cost not just of development, but of the life cycle as a whole, including maintenance and future evolution.

The strategy of the program concerned the establishment of a Software Production Center to enable large organizations to try out real, new techniques before making the necessary in-house investment, and to enable small companies to experience the benefits of new technology.

As a medium-term objective the strategy included the concept of a National Software Quality Certification Center.

Finally, the strategy set out to create a community by breaking down barriers between academics and industry.

The goal that by 1989 the UK should be a world leader in information systems factories was always an ambitious one. The achievement of integrated, system-wide methodologic support embracing software, hardware, and knowledge-based components is unlikely to be achieved in this decade. However the goal remains an excellent focus of attention.

It remains true that the acquisition and effective use of integrated support environments will form a major component

of the increasing capitalization of the software industry. The UK must play a full role.

The strategy identified five crucial areas of technical development:

1. Integrated systems development. This embraces the total software engineering process, with its associated developmental strategies and managerial controls; technical methodologies controls for the various phases of the life cycle; and the tools and environments to support these activities. The program has made considerable investments in the area of tools and environments. Considerable preparatory research is necessary for the third generation integrated programming systems environment (IPSE) and, consequently, a program of development for IKBS tools was begun. Work is being supported on the development or refinement of technical methodologies, but little has been proposed on understanding, assessing, and improving the software engineering process. This is a weakness in the program and should be remedied.

2. Reusability. The reuse of software and hardware components, though attractive, is very hard to achieve. Not much progress has been made.

3. Automatic software generation. Fourth generation languages are designed to generate software automatically from a high-level specification. This subject was already getting much attention, and a decision was made not to compete with such activity. Attention was instead concentrated on the Formal Methods Program. This work is based on languages underpinned with mathematical rigor, and therefore there is the possibility for high levels of automation to be applied to the generation of executable systems.

4. Formal specification and measurement. A strategy for the formal methods part of the program was published in April, 1984. The specific objectives of the program were to:

- Establish a coherent set of formal methods to support the life cycle of system development as a whole
- Create a body of engineers skilled in these formal methods
- Create integrated sets of tools to support the methods.

Within the 5-year strategy of the Alvey Program the focus was on:

- Existing mature methods, which were to be evaluated and industrialized
- Promising methods, which were to be the subject of research and development
- Developing a core group of engineers who were to be fluent in one or more mature methods

- Fostering appreciation of the fundamental concepts of formal methods among 30 percent of the UK software engineering community
- Development of experimental tools such as theorem provers and proof checkers for the mature methods.

To support the strategy the program has funded:

- Ten academic projects on the fundamentals of logic and proof as applied to software
- The establishment, jointly with SERC and a number of industrial partners, of a laboratory for the foundations of computer science at Edinburgh University
- A course on the mathematics of programming (books and video)
- A project developing a complete methodology for the capture and formalization of requirements
- Two projects making trial use of formal methods for software specification and communications protocols
- Two projects developing tool sets: one for VDM and one for Z and CSP
- Three projects applying verification techniques to hardware and microcode
- Seminars and an awareness campaign including a video for managers.

5. *Quality assurance and certification.* The program has supported projects concerned with the theory of software quality (in particular reliability), what is meant by it, and how it can be measured and achieved. The major projects are dealing with:

- Testing and its role in quality management
- Mathematical models which aim to predict the reliability of software and its evolution over the life history of a product
- The accumulation of a large data bank of all kinds of measurements related to software development and use with a view to testing mathematical predictive models and providing management with practical methods and guidelines to achieve specifiable goals
- Criteria which can be applied for the issuing of a software validation certificate
- Research into reliable, distributed systems.

#### D.E. Talbot on Harnessing IKBS

The strategy for the part of Software Engineering concerned with the exploitation of IKBS techniques was described in *Strategy for Knowledge Based IPSE Development*, published in 1984. As

well as seeking to ensure that the UK has the expertise needed for the design of a knowledge-based IPSE, it identified a program of research and development for tools which would exploit and demonstrate IKBS techniques, including those emerging from the Alvey IKBS Program. It was intended that such tools would appeal to a wide spectrum of developers of information systems and so alert the market to the potential benefits of intelligent tools, and of the use of IKBS techniques within the context of a sound software engineering approach.

This strategy was intended to bridge the cultural gap between the IKBS and software engineering communities with their different concerns, objectives, and terminologies.

The outcome has been that projects are being supported to build tools for requirements analysis, design, software estimation, and code generation. Also, a project is being funded to do preliminary research into the use of IKBS techniques in IPSE's and these techniques will play a large role in the planned third generation IPSE study.

The IKBS field has two major contributions to make to the construction of information systems: a range of techniques which permit computers to exhibit sophisticated behavior, and a developmental style which might be described as experimental programming or very fast prototyping.

The current program is showing that IKBS techniques can be imported into systems which would otherwise be regarded purely as creations of software engineering.

The movement of software engineering is away from experimental programming towards a very deliberate and controlled mode of development. The IKBS developmental style can be applied to advantage in areas where experimentation is likely to yield dividends, such as during requirement specification, when evolving the human interface and when solving intricate problems.

Our view, Talbot said, is that software engineering and IKBS must cease to be regarded as two separate disciplines. A competent systems engineer will be expected to be familiar with all the tools and techniques now offered by the two fields.

#### C.W.M. Barrow--The Man Machine Interface (MMI) Program

Alvey MMI is made up of the human interface, speech processing, image processing and displays.

Human Interface. In the human interface portion the design process has been divided into five phases:



1. Analysis of system requirements includes such design decisions as to which of the activities will be carried out by the user and which are to be incorporated in the machine.

2. Conceptional designs include the techniques of user modeling.

3. Prototyping and early evaluation tools are needed to make the conceptual design step as rapid and effective as possible.

4. The detailed design and implementation uses the specification from the previous phase to produce the final design.

5. The user and field trials phase involves predicting the effect on organizations of the introduction of information technology systems and an evaluation service to enable clients to obtain an objective and expert assessment of its information technology products.

Speech Processing. The speech processing work has been divided into four major areas:

1. Basic techniques includes algorithms and feature extraction.

2. Systems and assessment includes projects associated with input (recognition) and output (synthesis).

3. Speech technology/assessment standards deals with performance and correct methods and procedures.

4. Support tools and infrastructure includes human factors.

Image Processing. The projects in this section cover four main areas:

1. Techniques explores particular aspects required in vision systems. For example, medical imaging has to deal with shapes very different from geometrical imaging. Shapes encountered in manufacturing may be capable of more formal description.

2. Applications (the project) explores problems as, for example, in real time visual inspection where calculations may be needed to be performed in parallel.

3. Architectures explores the use of array processors, single instruction multiple data (SIMD), and multiple instruction multiple data (MIMD) machines.

4. Tools and infrastructures includes image coding, processing of radiological images, novel techniques for object detection and tracing, and real-time two-dimensional vision systems.

Displays. The six projects included here are two in liquid-crystal technology, two in electroluminescent technology, and two in human factors:

1. The liquid crystal silicon matrix project is to produce a display cap-

able of displaying 5500 alpha numeric characters. Each pixel is individually addressable via a matrix of polycrystalline thin-film transistors.

2. The large panel storage display project is to develop and demonstrate a rectangular ferro-electric liquid-crystal storage display of more than 10 inches diagonal.

3. The thin-film electroluminescent (EL) display project is to develop a display using improved thick-film techniques.

4. The interactive DC powder EL devices and systems project is to improve the performance of such displays in size, drive capability, and reliability.

5. The TV system with enhanced depth sensation project will attempt to create the illusion of a three-dimensional display by suppressing the flatness cues as seen by the viewer.

#### Alan Bagshaw and Ronan Sleep--Systems Architecture

The largest project in the systems architecture has been funded at £9 million and the total architecture funding amounts to £19 million.

The strategy of the architecture program is to regard architecture as an interface between applications and technology. It is clear that advanced applications require advanced technology and that the strengths in technology are there for exploitation. The Alvey architecture program can be a nucleus for European cooperation.

The aim of the program is to integrate the architectural community and to amplify the existing strengths to make an impact in the 1990's.

The first Alice machine was delivered to Imperial College, London, in June 1986. This system, based on transputer building blocks, is designed to work with logic programming and functional programming languages. It contains 137 transputers and consists of 32 graph-reduction units, which means 32 graph-reduction operations can proceed in parallel.

A generic associative memory chip has been produced and tested.

Bagshaw and Sleep said they believe that much architecture is technology-driven when it should be application-driven and that more progress is needed in international collaboration.

#### Comments

The Alvey Program is now moving into its 4th year of a 5-year program. While it is still too early to judge its overall success, it has certainly made progress to date. That progress is, I believe, most noteworthy in VLSI and in systems architecture. Interestingly, systems architecture was an afterthought



and brought into the program a year after its start.

In the VLSI program a variety of circuits using 1.5-micron silicon technology have been demonstrated in CMOS and bipolar versions. Indications are that the target of having 1-micron technologies in both CMOS and bipolar ready for transfer to production by 1989 will be achieved. This will not make the UK the world leader but will put them in the race. Since semiconductor technology drives both the computer industry and the telecommunications industry it was wise for the Alvey Program to put more than £60 million of its £200 million public funds into the VLSI program.

It was unwise to leave systems architecture out originally but that has now been corrected and progress is being made in this area. The separated programs at Imperial College and Manchester University have been combined in the Alvey Flagship project, now funded at £19 million. ICL, Britain's only large main-frame manufacturer has been brought into the program, and a prototype, highly parallel graph-reduction system has been delivered to Imperial College. This machine is based on the INMOS transputer, another important innovation in the UK.

For the first time ever there is extensive collaboration between UK universities and UK manufacturers in the information technology industry. This collaboration will play an important part in the future success of the UK in the European market for IT products.

8/15/86

## Environmental Sciences

### INTERNATIONAL CONFERENCE ON OPTICAL AND MILLIMETER WAVE PROPAGATION AND SCATTERING IN THE ATMOSPHERE

*by Jerome Williams. Professor Williams is the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until December 1987 from the US Naval Academy, where he is Associate Chairman of the Oceanography Department.*

This conference, held in Florence, Italy, under the auspices of a number of

international organizations, was organized jointly by Anna Consortini of the Department of Physics of the University of Florence and Richard Elliott of the Oregon Graduate Center. They did an outstanding job, attracting about 200 participants from 15 different countries, representing Asia, North America, the Mid-East, Europe, and Australia. About 30 percent of the participants were from the US.

### Introduction

The objective of the conference was to address all aspects of propagation and scattering of optical and millimeter waves in the atmosphere by providing a forum for the presentation of most recent research results by active researchers in the field from around the world. The program included review papers by invited speakers in selected topic areas, but the major portion of the meeting was devoted to presenting the results of recent research. One of the major disappointments of the conference was the fact that none of the Russian participants, many of whom are working in areas of major interest, were present. In general, the papers were heavily weighted towards theory, but some experimental data were presented. Unfortunately, most of these experimental data represented laboratory studies rather than studies made in the environment. The conference was divided into sections, each devoted to a specific topic area. For convenience, I will report them as: Scintillation Theory, Imaging and Transmission, Remote Sensing, Nonlinear Effects, Surface Scattering, and Particle Scattering.

### Scintillation Theory

The conference was opened by H.T. Yura (Aerospace Corporation, Los Angeles), who described an elementary derivation of the phenomenon of scintillation saturation by the generalization of Tatarski's geometric optical models. This was followed by S. Flatté (University of California, Santa Cruz), who showed a technique to describe scintillation by utilizing the Feynman path integral.

Emil Wolf (University of Rochester, New York), one of the featured invited speakers, presented a tutorial paper involving some recent developments in optical coherence theory.

B. Jakeman (Royal Signals and Radar Establishment, UK) described a first theoretical step in using the statistical properties of rays propagating through a refracting medium. Effects visible to the naked eye are generally geometrical in origin and associated with scattering of incoherent light; thus the performance of many simple optical instruments which

are used to enhance our natural eyesight is limited by refraction. The mathematical difficulty of investigating full diffraction-limited geometrical optics is well known, so that what is required is a multiscale model which will generate ray effects but not geometrical singularities. These are indeed the properties of the class of subfractal, or fractal, slope models which Jakeman is in the process of investigating.

An interesting aspect of the scintillation problem is suggested by the possibility that two beams, each of a different frequency but sent through the same scintillating medium, may be affected in a different manner. M. Tur (Tel-Aviv University) and Z. Azar and E. Azoulay (Soreq Nuclear Research Center, Israel) described a study which attempted to develop a mathematical description of the correlation between the intensity fluctuation of two such beams. They hope that comparisons between experimentally determined bichromatic correlations and their theoretical, calculated counterparts will refine the models used to describe the refraction index correlation function of the medium. If the correlation coefficient is high, a cheap and weak optical source at one wavelength can be used to probe the medium and locate high-transmission, short-lived time windows, so that a stronger and inevitably more expensive source may be used to successfully transmit information.

The Israeli group used a two-frequency fourth moment equation in the strong, multiple-scattering regime, which resulted in a closed-form (though approximate and difficult to evaluate) expression for this bichromatic covariance function. The IR results indicate that small turbulent eddies increase their relative effectiveness in increasing signal loss as turbulence becomes stronger.

Three other investigators from Israel, N. Ben-Yosef, E. Goldner, and A. Weitz (Hebrew University of Jerusalem) reported on some further work in determining the correlation in the intensity fluctuations of two beams transmitting through the same medium. This work indicated that the linear scale goes down as turbulence increases, and the correlation of temperature fluctuations tends to increase as physical perturbations decrease. Both temperature fluctuations and physical perturbations are associated with turbulence.

#### Imaging and Transmission

One of the primary considerations that drives research in atmospheric scintillation is the effect that scintillation has on the transmission of electromagnetic energy through the atmosphere

and the effect variation in amplitude has on imaging properties. One aspect of the transmission problem is the phenomenon of speckle. Speckle results when an image of a beam transmitted through a turbulent atmosphere is averaged over a period of time. Under these conditions, the image of the beam is spread out over a large physical area.

J.C. Dainty (Imperial College, London) discussed a variety of techniques called "speckle imaging" which are used to produce an object map. This is a map of the object intensity derived from short-exposure speckle data. Although no totally satisfactory method of speckle imaging has yet been implemented routinely in astronomy, he discussed several proposed techniques that look reasonably promising. These same techniques can be used for atmospheric sounding, as was discussed later in the conference.

The estimation of the phase function is a major problem in the reconstruction of a stellar object's complex spatial spectrum from a set of speckle images. G. Aitken, R. Johnson and H. Houtman (Queens University, Canada) suggested an approach that measured a two-dimensional array of phase differences between adjacent spatial-frequency components to determine the phase function by either summing outward from the origin or fitting a function to the array of phase differences. The process described estimates the true phase gradient directly from the speckle images. The important property of this process is that the noise biases at low photon levels are somewhat less troublesome than in previous processes and, in principle, can be systematically removed during data reduction.

A group in Beijing, China, led by J. Wang (Chinese Academy of Space Technology) and a similar group in Rome led by U. Merlo and E. Fionda (Fondazione University Bordoni) have been involved in a cooperative venture attempting to compare the atmospheric scintillations measured in similar path lengths near Beijing and Rome. Measurements were made over two links with the SIRIO Satellite at these two sites, and a simple but effective evaluation of the diurnal evolution of turbulence induced by solar heating was noted. A noticeable variability of mean scintillation intensity index has been found at both locations, particularly around 1030 and 1730 local time. This behavior can be approximately related to the daily ground temperature cycle.

R. Cole (University College, London) set up a 4-km line-of-sight path across central London and used a 60-GHz radar system to measure the amplitude and phase scintillation of the radar beam as it passed over this urban region. He

compared the actual measurements with a theoretical model derived from the basic work of Tatarski. The data seemed to show the characteristic minus  $8/3$  slope for the amplitude scintillation spectrum as predicted by Tatarski.

As part of a large study involving multisensor assessment, atmospheric transmission measurements were made at visible, IR, and millimeter wavelengths, with ranges varying from 4 to 12 km over sea, and 0.5 to 6 km over land. Relevant meteorological measurements along with measurements of the size distribution of aerosols and rain drops were made coincidentally. A portion of this large study was reported by A. Kohnle, R. Neuwirth, W. Steffens and H. Junolt (Forschungsinstitut für Optik, Tübingen, West Germany). A number of anomalies were noted, including the apparent fact that contributions to atmospheric transmission by molecular and continuum terms are both greater than the Air Force Geophysical Laboratory Standard. When compared to millimeter wave transmissions, the IR transmission in rain is different for different rain rates, for different path lengths, and where fog and rain are clearly differentiated. For the infrared with aerosols present, the aerosols typically only accounted for about 2 percent of the total attenuation, with January measurements markedly different from those made in July. Calculations based on standard size distributions for maritime and continental air masses showed these calculated transmitted values to have large data spreads when compared with measured values at a path length of 5.4 km. The study indicated that the simple models of drop size distribution and aerosol content are not valid under real conditions.

E. Baars (Forschungsinstitut für Hochfrequenzphysik, West Germany) presented the results of a experimental investigation of millimeter wave propagation in the atmosphere during which radar propagation at 47 and 94 GHz was compared with infrared. He found that rain attenuation at both radar frequencies is well described by the Mie Theory, as long as the calculation is based on actual measured drop size distribution. If this distribution is not known then the attenuation may be in error by a large amount. He found that rain attenuation at 94 GHz was larger than at 47 GHz but was comparable to the IR windows. Attenuation due to sleet and wet snow was found to be lower than for rain at a comparable water equivalent precipitation rate. Other particulates such as dry snow, hail, haze, fog, smoke, and dust seem to have no significant influence on millimeter wave transmission but do cause severe restrictions on IR transmissions.

#### Remote Sensing

T. Wilkerson (University of Maryland) described some problems inherent in light detection and ranging (LIDAR) systems utilized for the profiling of atmospheric properties. LIDAR technology is now available for profiling temperature, pressure, density, and humidity in the atmosphere. Present accuracies available using LIDAR technology are about  $\pm 1$  degree C for temperature, about  $\pm 3$  mb for pressure,  $\pm 0.3$  percent for density measurements, and  $\pm 3$  percent for humidity measurements. What is usually done to measure these atmospheric properties is to employ two different wavelength laser beams simultaneously and measure the difference in absorption of these two beams. One is centered on an absorption band for the parameter being measured, while the other is off frequency a small amount, so there will be some difference seen. This process is called Differential Absorption LIDAR (DIAL). Time-resolved analysis of the ratio of two LIDAR returns provides a range-resolved profile of the amount of the absorber. This is a very powerful tool but is obviously limited by the characteristics of the atmosphere, especially those having to do with turbulence. This was discussed in some detail by G. Megie (Service d'Aéronomie du CNRS, France). Megie indicated that the wavelengths usually used in DIAL systems were in the ultraviolet (270 to 350 nm) and both the near- and far-infrared (700 to 10,000 nm). For optimum results in a system such as this a time lag of less than one second between the two readings is necessary.

A group at the Lund Institute of Technology (Sweden) including H. Edner, B. Galle, A. Sunesson, S. Svanberg, L. Unéas, S. Wallin and W. Wendt described a system for atmospheric pollution monitoring which is in operation at the present time. Using this system, the Swedish group is able to measure  $\text{SO}_2$ ,  $\text{NO}_2$ ,  $\text{NO}_x$ ,  $\text{O}_3$ , and Hg by very cleverly utilizing the return energy from the LIDAR signals at different wave lengths. Using plots of returned LIDAR intensity vs. range, the rate of decay of returned energy can show how much of each substance is present. Attempts to get the required differing wavelength measurements as close together in time as possible has resulted in a system that allows the measurements to be accomplished in less than 10 ms. The set of instruments described by the Swedish group is small enough to be placed in a tractor trailer, so it can be transported any place there is a suspected pollution problem.

W. Büchtemann and R. Ebert (Forschungsinstitut für Optik) described a  $\text{CO}_2$  laser LIDAR system and some

environmental effects they have noticed in the use of this system. With moderate path lengths and moderate to strong turbulence, measurements of phase fluctuations using this CO<sub>2</sub> laser system show good agreement with theory.

A slightly different application of the LIDAR principle was described by J. Holmes of the Oregon Graduate Center. He uses a LIDAR system to measure the wind-speed component perpendicular to the laser beam direction. Speckle turbulence interaction has the potential of allowing single-ended remote sensing of the path-averaged vector crosswind. If a laser transmitter is used to illuminate a target, the speckle field resulting from target reflectance is randomly perturbed by the atmosphere, creating a scintillation pattern at the receiver. If a crosswind is present, this pattern will move across the field of view of the receiver. Consequently, the time-delayed statistics of the receiver speckle field are dependent upon the crosswind velocity and can be used to determine the crosswind component.

Holmes used a direct-detection receiver requiring a pulsed transmitter, and since time-delayed statistics were required, it was necessary that the transmitter be double pulsed. This resulted in a complicated and rather expensive transmitter that was plagued by problems of beam alignment, beam jitter, stability, and reliability. Nevertheless, enough good experimental data were obtained to indicate that the speckle turbulence technique has merit in remote wind measurement.

An interesting and somewhat different approach to the measurement of atmospheric turbulence profiles was suggested by S. Clifford and J. Churnside (NOAA Wave Propagation Laboratory, Boulder). The technique suggested involved the use of a synthetic aperture analysis system in conjunction with a light source. The light source is flown from an airplane at a speed much faster than the atmospheric motion intervening between the source and the ground. On the ground is a sinusoidal receiver array. Because of the rapid translation of the aircraft, the intrinsic speed of the medium may be ignored, and to the observer on the ground the atmosphere appears to have a velocity profile that rotates about the receiver. This system is conceptually identical with the synthetic aperture system used in radar. By using this methodology, it is possible to interrogate the medium at any height between the receiver and the aircraft, and thereby infer the refractive index structure parameter at that altitude. At this point the instrument is still in the theoretical phase, and

there has been no actual hardware developed to test the concept.

If a light source is observed through a turbulent medium such as the atmosphere, scintillations are noted due to time variations in the refractive index. Since the refractive index is related to temperature and humidity conditions, it is possible to use these variations to determine heat and moisture fluxes. The methodology used by W. Kohsiek (Royal Netherlands Meteorological Institute, Netherlands) was to use the scintillation spectrum from a transmitter and receiver system separated by a distance between 8 and 10 km to determine the parameters necessary to calculate the heat and moisture fluxes. In order to do this, Kohsiek used three different wavelengths: 1 cm, 10.6  $\mu$ m and 0.94  $\mu$ m. The theory to support this was developed and some data actually obtained were shown, indicating that the method might very well have a great deal of promise.

J. Vernin and J. Caccia (Université de Nice, France) described another method for the measurement of turbulent layers in the atmosphere by using speckle patterns taken from photographs of star images. With the knowledge of the theoretical shapes of the space and time correlations of atmospheric speckle patterns, it is possible to determine the altitude and the turbulent intensity of each turbulent layer. The theory is not yet complete, but some preliminary results were presented.

G. Ortgies (Forschungsinstitut der Deutschen Bundespost beim Fernmeldetechnischen Zentralamt, West Germany) has also pursued the use of scintillation measurements to determine some atmospheric characteristics. He used two different frequency signals with the OTS satellite to obtain data relating the temperature and water vapor content to the turbulent intensity of the received signals.

An experiment by W. Porch and L. Rosen (Lawrence Livermore National Laboratory, California) and W. Neff (NOAA, Boulder) involved the utilization of acoustic sounders and LIDAR crosswind sensors, colocated in the same region. The arrangement allowed comparison of the temperature structure derived from the acoustic sounder with the index of refraction structure derived from optical turbulence measurements. The resulting data agree in form but seem to differ in frequency of variability. This difference between optical and acoustic sounders is greatest at the low turbulence levels.

A paper summarizing the results of a study to investigate the retrieval of atmospheric water vapor profiles over

land and water from several combinations of different frequency millimeter wave channels was presented by R. Isaacs, G. Deblonde, R. Worsham, and L. Kaplan (Atmospheric and Environmental Research Inc., Massachusetts). The authors found that it was easier to obtain the integrated value of water vapor than the profile details. They also found that millimeter wave vertical moisture retrievals over land are degraded in quality as compared to those potentially obtainable over the ocean.

#### Nonlinear Effects

As a light beam is propagated through the atmosphere and reacts with aerosols along the beam path, various effects are noted. If the beam is of weak or moderate intensity, diffusive evaporation and conductive heat transfer are the dominant effects. If the radiance of the beam is increased, convective evaporation occurs, associated with external shocks. A further increase in beam radiance will produce explosive vaporization of drops in conjunction with internal shocks. A further increase in the intensity of the beam will cause even clean air to break down.

Richard Chang (Yale University) has studied some of these effects and showed some actual photographs of liquid droplets being affected by laser energy. In the wavelength region where there is no optical absorption by pure water, high-intensity laser beams can still induce droplet heating via several nonlinear optical mechanisms. These mechanisms have been observed in the laboratory using lasers in the sub GW/cm<sup>2</sup> range to irradiate a single water droplet flowing in a linear stream. These results suggest that the stimulated Raman process, known to coherently induce vibronic transitions, may lead to droplet vaporization and that the stimulated Brillouin process, known to coherently induce pressure waves, may lead to droplet shattering.

R.L. Armstrong (New Mexico State University) continued the discussion of these nonlinear effects on aerosols. He was particularly concerned with the effects of shock waves produced by the conversion of laser energy when interacting with droplets. In this convected mass/flux regime the multicomponent hydrodynamic equations for the aerosol vapor and the ambient atmosphere must be solved subject to the appropriate boundary conditions at the aerosol interface. Numerical solutions to the hydrodynamic equations were obtained using an extension of the CONID hydrodynamics code. This was modified by the inclusion of a high-irradiance source term and the addition of jump conditions at the aerosol boundary.

The results of these calculations were presented for both liquid and solid aerosols irradiated by high-flux laser beams.

Following on the hydrodynamic approach, M. Lax and B. Yudanin (City College of New York) presented a study involving the solution of the time-dependent coupled problem resulting from the interaction of the laser beam and the aerosol droplets. The complete time-dependent coupled problem does not appear soluble at present. Some simplifications were made based on the difference in the interaction mechanisms at different time intervals. If the pulse time is short compared to the hydrodynamic response time the energy is absorbed with essentially no motion, after which there will be hydrodynamic response with no absorption. This means there exists a time interval (perhaps  $10^{-9}$  to  $10^{-7}$  seconds) in which a purely hydrodynamic response may be assumed. The solution of this short-time hydrodynamic problem provides an initial condition to later events which are influenced by thermal processes.

A laboratory effort just beginning by L. Crescentini and G. Fiocco (Università "La Sapienza", Rome) is involved with the simulation of the effects expected by the passage of a relatively strong laser beam. These effects include degradation of the beam by self-induced modifications of the refractive index; transition of the regimes between diffusion and convection; and convective instability induced in an initially motionless volume of air by the *in situ* introduction of heat. In order to do this a Michelson Interferometer was used and fringe patterns were photographed. Preliminary experiments indicated that differences in temperature on the order of 0.01°C can be detected for heat dissipation of a few mW/m<sup>2</sup> in a steady-state condition. Such a temperature field displays strong vertical asymmetry indicative of the presence of convection. Experiments were limited by the sensitivity and resolution of the detector and the instrumentation is being upgraded to overcome these limitations.

Surface reflection when the surface is not the target can be a problem, as emphasized by H. Essen and E. Baars (Forschungsinstitut für Hochfrequenzphysik, Wächtberg, West Germany). In their discussion of the effect of radar reflection from snow-covered terrain, not only may backscatter from the snow surface impose problems but the possibility of performance degradation due to multipath propagation has to be considered. Under most conditions snow-covered terrain does not present much more of a problem than typical agricultural conditions. A particular

kind of rough surface wherein the roughness is about the same order of magnitude in length as the wavelength of the EM energy impingent was treated by E. Mendez, K. O'Donnell and A. Harley (Imperial College, London). They developed a theoretical model, and some experimental data using a CO<sub>2</sub> laser with a wavelength of 10.6  $\mu\text{m}$  were shown to support the theory.

R. Schiffer and K. Thielheim (Institut für Reine und Angewandte Kernphysik, West Germany) treated the problem of a rough scattering surface falling between the extremes of very small characteristic roughness lengths and very large characteristic roughness lengths. As most natural surfaces do not fall within the scope of either one of these limiting cases, the construction of a surface model with composite roughness was accomplished. The authors improved upon previous composite models and were able to obtain a reduced and reddened reflectance, in addition to reproducing depolarization of the backscattering intensity, just as occurs under natural conditions.

#### Particle Scattering

A study primarily concerned with scattering very close to the axis of transmission was reported by A. Zardecki and S. Gerstl (Los Alamos National Laboratory). They looked at multiple scattering at very small angles to the propagation axis and found that the small angle approximation remains valid as long as the angles are on the order of the angular spread of the scattering phase function. However, for somewhat larger angles their theory only accounted for about 50 percent of the scattered energy.

Nonspherical particles were treated by a number of the speakers, the first presentation being from a paper by V.V. Varadan and V.K. Varadan (Pennsylvania State University). They simulated the positional, angle-dependent correlations of nonspherical particles using Monte Carlo simulation and an expansion of the two scatterer correlation functions in Legendre polynomials. These values were used in calculating the effective wave number of the coherent field for media containing aligned spheroidal scatterers which they compared with previous results using spherical statistics.

A. Mugnai (Istituto di Fisica dell'Atmosfera, Italy) and W. Wiscombe and C. Frascata (NASA, Goddard) described scattering from a number of different nonspherical Chevyshev particles. Using the extended boundary condition method they computed the phase function, as well as the scattering and absorption efficiencies; the single scattering albedo; the asymmetry factor; and the backscattered fraction for isotropically incident radi-

ation on a rather general class of rotationally symmetric nonspherical particles.

Scattering calculations were carried out for 23 different particle shapes, all with a refractive index of about 1.5. Particles ranged in shape from smooth surface oblate spheroids to bumpy particulate shapes. They found that the differences between nonspherical particles and spherical particles were greatest in the side- and backscattering regime, since this region is most sensitive to particle shape. Light scattering is definitely enhanced by nonsphericity, but for larger size particles all nonspherical phase functions tend to be smaller for scattering angles less than about 100 degrees.

The problem of multiscattering was also addressed by a number of investigators, the first of these being L. Bissonnette (Defense Research Establishment, UK). He described a multiscattering propagation model and compared predictions from this model with measurements performed in laboratory-generated water droplet clouds. Drop sizes in his clouds varied between 0.1 and 15  $\mu\text{m}$  with a peak near 1  $\mu\text{m}$ . The concentrations were varied from 0 to about 5 grams per cubic meter corresponding to extinction coefficients at 0.63  $\mu\text{m}$  between 0 and 3 per meter. Scattering measurements were performed with three lasers having wave lengths of 0.63, 1.06, and 10.6  $\mu\text{m}$ , resulting in very good agreement between measured and theoretical values of beam broadening except at large distances from the beam axis.

G. Zaccanti, P. Brusaglioni, and P. Pili (Università di Firenze, Italy) presented the results of laboratory measurements pertaining to the transmission of a helium-neon laser light beam, through latex sphere suspensions. Comparisons were made with predictions determined from theory using suspensions of single-size polystyrene spheres with radii ranging from 0.15 to 7.85  $\mu\text{m}$ . Measured values corresponded very well with the calculated values only if a large number of orders of scattering were considered, indicating that multiple scattering is indeed very important in real systems.

Taking a different tack, M. Kleiman, I. Ariel, and S. Egert (Institute for Biological Research, Ness-Ziona, Israel) and A. Cohen (Hebrew University of Jerusalem) studied particles having multiple layers. Usually, scattering coefficients for specific particles are assumed to be constant throughout the volume of the particle involved. In this case, the authors developed a general theoretical solution for a multiple-layered scattering sphere for which each layer is



allowed to have any desired complex refractive index and permeability.

F. Prodi, V. Levizzani, and G. Casarini (Istituto FISBAT-CNR, Bologna, Italy) reported on a theoretical treatment of particle populations wherein each range of particle sizes was allowed to have different optical characteristics. Their optical apparatus was a polar nephelometer with the scattering volume consisting of a filter containing particles within a carefully determined size range. Measurements were made on Sahara dust particles obtained from deposits of muddy rains at the ground and subsequently aerosolized, on rural plus anthropogenic aerosols, and on latex spheres as standardized samples for comparison.

Optical propagation and communications through clouds was studied by G. Lee, J. Rockway, B. Speer, and G. Mooredian (Titan Systems Inc., California) as part of a program in progress since 1979. Their paper discussed the results of several recent experiments performed in a wide range of cloud conditions, including stratus clouds off the California coast, winter frontal clouds in Oregon, and tropical cumulus clouds on the wet side of two Hawaiian Islands. Each experiment was different, but usually simultaneous measurements were made of the received pulse energy, pulse width, and receiver signal-to-noise ratio from an airborne visible laser, while various kinds of *in situ* cloud measurements were performed. Solar irradiance was also measured at the ground station and used to infer the cloud optical thickness.

In parallel with the experiments, analytical models for cloud propagation losses were developed using Monte Carlo simulations while assuming uniform, plane parallel clouds having an assumed cloud optical thickness. At this point the following conclusions were drawn. Values of the cloud optical thickness, both measured and calculated, compared very well when the nephelometer data were used. However, when the value of cloud optical thickness was inferred from measurements of cloud droplet spectra by Knollenberg probes they were typically a factor of two lower. Values of cloud optical thickness estimated from values in the literature were less by up to a factor of 5 to 10 than the values inferred from solar irradiance for thick clouds in Oregon. This may be due to the fact that the thick winter clouds contain large amounts of ice and thus have smaller extinction coefficients. Inference of the cloud optical thickness from satellite estimates of reflectance were compared with airborne and ground measurements. The accuracy of present methods are limited for large values of optical

thickness by sensor error in measuring reflected energy and for small values of optical thickness by the sensitivity of the reflectance function to sun and satellite angle.

#### Summary

This conference provided an opportunity for atmospheric scientists from all over the world to gather and exchange ideas and data. Perhaps more importantly, it provided an opportunity for theoreticians and experimentalists to exchange ideas. At many points it was obvious that many theoreticians were markedly cut off from the real environment, and the experimentalists were not aware of some modern theoretical work being done. Consequently, I believe the conference was of great value to all concerned and will probably aid in the successful accomplishment of future research. It appears that scattering theory is progressing at a reasonable rate although at a somewhat more rapid rate in the US than Europe. The same comment also applies to data analysis methods associated with scintillation in the atmosphere. Although a major portion of the science reported was by US scientists, it was also obvious that scientists from other countries were making rather important contributions, both in the theoretical and experimental arenas.

8/15/86

## Material Sciences

### ION BEAM MODIFICATION OF MATERIALS, IBMM 86

by Louis Cartz. Dr. Cartz is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Marquette University, College of Engineering, Milwaukee, Wisconsin.

The Ion Beam Modification of Materials conferences are held every 2 years, the 1986 meeting being in Catania, Italy (the 1988 meeting to be held in Japan). More than 300 scientists were present, most of them from Western Europe, with 45 from North America, 31 from the Far East, and four from Eastern Europe. No representative of the USSR was present even

though three poster sessions were offered on their behalf. The ONR provided partial financial support towards this conference.

The topics covered at the conference were divided into sessions on ion implantation in semiconductors, in insulators, in ceramics, and in metals. Other sessions concerned energy deposition and ion ranges, ion beam mixing, reactive ion etching, and amorphization by ion beams.

A wide range of materials was examined after ion implantation including ceramics, plastics, and metals. I have listed the materials in Table 1 and the ion species and energies used in the implantations in Table 2. With a few exceptions, the studies have used ion beams of energies of the order of 100 keV. Consequently, only the upper 100 nm of surface are generally modified, and this fact dictates the types of experimental techniques available for examining the thin surface layer. The various experimental techniques are listed in Table 3, and the properties investigated are given in Table 4. (A consolidated table of materials, implantations, methods used, and properties examined would be impractical and could be misleading, hence the separate tables.) Most studies seemed to

apply RBS and SEM to examine both single-crystal and polycrystalline materials. The complete conference proceedings are to be published in *Nuclear Instruments and Methods in Physics Research B* so I will describe here only items of special interest.

Table 1

## Materials Examined

Ceramics

|   |                  |
|---|------------------|
| $\alpha$ -Al <sub>2</sub> O <sub>3</sub>            | SiC              |
| Several Silicides                                   | WC               |
| Diamond   | Graphite         |
| TiB <sub>2</sub>                                    | TiO <sub>2</sub> |
| LiNbO <sub>3</sub>                                  | LiF              |
| Garnets   |                  |
| Y <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub> YIG  |                  |
| Y <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> YAG  |                  |
| Gd <sub>3</sub> Ga <sub>5</sub> O <sub>12</sub> GGG |                  |
| Various Glasses                                     | SiO <sub>2</sub> |

Metals

|   |
|---|
| Al, Cu, Ag, Ni, Zr, Mo                      |
| Ti, W                                       |
| Cast Fe, (Austenite and Martensitic Steels) |
| Ti-Al-V alloys                              |
| Ti-Ni alloys                                |
| Al-Ni alloys                                |
| Al-Si-Ge                                    |
| CoCrAl coatings                             |

Plastics (incomplete list)

|                        |
|------------------------|
| PS Polystyrene         |
| Polyimides Kapton      |
| PDA (polydiacetylenes) |

Semi Conductors (incomplete list)

|               |
|---------------|
| Si, GaAs, InP |
|---------------|

Table 2

## Implanted Ions

| Ion        | Energies (keV) | Ions Fluence/cm <sup>2</sup>           |
|------------|----------------|--|
| Ba         | 50-150         | 10 <sup>15</sup> -2×10 <sup>16</sup>   |
| Ar, Cu, Zn | 150            | 10 <sup>15</sup> -10 <sup>17</sup>     |
| He, Ne     | 35-100         |  |
| B          | 30-135         | 10 <sup>17</sup>                       |
|            | 3000-4000      |  |
| N          | 30             | 1-9.9×10 <sup>17</sup>                 |
|            | 350            | 10 <sup>18</sup>                       |
| Ti, V      | 30             | 1-5×10 <sup>17</sup>                   |
| Al         | 25-170         | 10 <sup>16</sup> -5×10 <sup>17</sup>   |
| C          | 20-150         | 5×10 <sup>17</sup>                     |
| O          | 35-70          | 4×10 <sup>17</sup>                     |
| Kr         | 500            | 2×10 <sup>16</sup>                     |
| Fe         | 100            | 10 <sup>15</sup> -10 <sup>17</sup>     |
| D          | 1-20           |  |
| H          | 40             |  |
| Zr         | 150            |  |
| In         | 100            | 5×10 <sup>14</sup> -5×10 <sup>16</sup> |
| Pb         | 50             | 5×10 <sup>14</sup> -5×10 <sup>16</sup> |
| Ne, Ar     | 45-3000        | 10 <sup>16</sup> -3×10 <sup>17</sup>   |

Table 3

## Experimental Techniques

|  |
|--|
| Micro-hardness   |
| Friction   |
| Scotch Tape Peel Test  |
| Sputter Etching  |
| Observation of Slip Lines  |
| Corrosion Resistance (Pitting Potential, Protection Potential Work Function) |
| Low Temperature Hot Corrosion (LTHC)   |
| Nuclear Reaction Analysis (NRA)  |
| Thermal Desorption Spectroscopy  |
| Scanning Electron Microscopy (SEM)   |
| Radioactive Isotope Diffusion  |
| Electrical Resistivity   |
| Grazing Incidence X-ray Diffraction  |
| Secondary Ion Mass Spectrometry (SIMS)                                       |
| Reactive Ion Mass Spectrometry (RIBE)  |
| Transmission Electron Microscopy (TEM)                                       |
| Raman Spectroscopy   |
| Rutherford Back-Scattering (RBS)   |
| Positron Annihilation Method   |
| X-ray Photoelectron Spectroscopy (XPS)                                       |
| Auger Electron Spectroscopy (AES)  |
| Fluorescence Extended X-ray Absorption Fine Structure (EXAFS)                |
| Photoluminescence (PL)   |
| Mössbauer Spectroscopy   |
| IR Transmission  |
| Electron Diffraction   |



Table 4

## Properties Investigated

Fatigue (crack initiation & propagation)  
 Wear Resistance  
 Friction  
 Corrosion (Surface protection)  
 Hardening  
 Subsurface Structural Modifications  
 Contact Resistance  
 Catalytical Behaviour  
 Adhesion of Thin Films to Substrates  
 Radiation Enhanced Diffusion  
 Self-Diffusion

## Surface Microstructure

The paper of S. Bartolucci-Lyckx, Y. Cassuto, T. Derry, and J.P.F. Sellschop (University of Witwatersrand, South Africa) was particularly interesting, being based on a simple set of observations yet giving an insight into the behavior of the material. They examined the effect of N implantation at 100 keV on WC single crystals at a fluence of  $10^{17}$  ions/cm<sup>2</sup>, and compared hardness indentations before and after irradiation. Before irradiation, only plastic deformation and slip steps were observed, while plastic deformation and cracks were observed after irradiation. This can be explained by the surface layer remaining plastic and the subsurface layer becoming embrittled where the implanted ions stop. To confirm this, Bartolucci-Lyckx et al. took TEM's of thin foils and were able to observe tangles of dislocations in the subsurface region.

In the case of many ceramic materials, an amorphous surface layer is formed by the irradiations. It is general practice in this context to use the term amorphous, which is perhaps unfortunate. The term "noncrystalline" would be a more precise description than "amorphous," "glassy," or "metamict." C.J. McHargue (ONR, Arlington, Virginia) reviewed ion implantation effects in ceramics; he considered the different cases when metastable solid solutions, crystal defects, or amorphous (noncrystalline) conditions are formed. He illustrated this by reference to  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>,  $\alpha$ -SiC, and TiB<sub>2</sub>, noting that the damage caused to the materials occurred to depths about twice the expected range of the bombarding ion. The radiation damage cross sections of these compounds to ion bombardment is not known (Kariotis et al., 1982), and it would be of interest to determine such damage for these compounds.

H.G. Bohn, C.J. McHargue, G.M. Begun, and J.M. Williams (ONR, Arlington) carried out a very careful ion irradiation

Table 5

## Matrix Materials Used for the Ion Beam Mixing Reactions

Silicides

Au-, Cr-, Ti-, Co-, Fe-, Pt- and other metal silicides

Multilayers

Ni/SiO<sub>2</sub>/Si

Ti/SiO<sub>2</sub>/Si

Al-Fe

Fe-Ti

Al-Si

Alloys

Ni Al

Ni Pb

Ag Cu

Ag Mo

Ti Pd

Other

Au/GaAs

InxWO<sub>3</sub>

GeCoAs (noncrystalline)

Al/AuCu

tion experiment on single crystals of  $\alpha$ -SiC to determine the damage and annealing characteristics of  $\alpha$ -SiC. Amorphous surface layers of 280 nm are reported for a Cr (260 keV) ion irradiation at a fluence of  $10^{16}$  ions/cm<sup>2</sup>. The damage was observed by RBS experiments, which did not permit the measurement of a damage cross section. The amorphous layer was found to recrystallize epitaxially at temperatures of about 1500°C.

Z. Guo-Liang and Y. Hong (Beijing University, China) implanted diamonds (type Ia) with N and B ions at 100 keV at fluence up to  $10^{16}$  ions/cm<sup>2</sup>. They reported an amorphous condition formed under irradiation; this is probably not noncrystalline since other workers using x-ray diffraction studies have observed that diamond undergoes an increase in lattice parameter with irradiation but remains crystalline (Wong et al., in print). Guo-Liang and Hong carried out very careful annealing studies using XPS and concluded that the damaged region converts to graphite at about 500-700°C.

Ion Beam Mixing Reactions

Over 100 papers and posters were presented at the meeting on this topic. A wide range of systems were examined, as indicated in Table 5.

Ion beam mixing of prepared multilayer superlattices was the subject of general studies. An interesting use of this technique was described by J.A.

Knapp and D.M. Follstaedt (Sandia National Laboratory, New Mexico). Alternate layers of Al and of Mn were deposited to a total thickness of about 150 nm, adjusted to about 16 atomic percent Mn. This multilayer was irradiated by Xe (100 keV) ions to a fluence of  $10^{16}$  ions/cm<sup>2</sup>. Ion beam mixing at 100°C results in a metastable Al-Mn icosahedral phase; otherwise heating to 300°C is necessary to obtain this phase.

Xi Xiao-xing (Peking University, Beijing, China) has examined the superconducting properties of multilayer films of AlSi after irradiation. A maximum layer thickness of 15 nm to a total thickness of 100 nm was used and irradiated by 80 keV Ar ions below 10 K. The superconducting critical temperature was found to increase with fluence.

#### Enhanced Adhesion

There is considerable interest in the enhancement of adhesion of thin-metal films to substrates by ion beam irradiation. R.E. Benenson, B. Daudin, P. Martin and M. Dubus (Centre Énergie Nucléaire [CENG], Grenoble, France) have carried out a series of experiments using 50 nm thick Au and Ni films on metals such as Zr, Ti, and Al, and glass using 2 MeV beams of N ions. The substrate surfaces were cleaned carefully in advance using organic solvents and, in the case of the glass substrate, preheating to 450°C. When a fluence of  $10^6$  Au ions/cm<sup>2</sup> are irradiated onto metal or glass and the substrate is kept cool, improved adhesion breaking strengths of 1 kPa are obtained. The researchers were able to show that the improved adhesion is not due to a sputtering effect because irradiations at steep angles resulted in a decrease of the adhesion, even though sputtering would be expected to increase in this case.

D.K. Sood and J.E.E. Baglin (Royal Melbourne Institute of Technology, Australia) described an extremely ingenious way of measuring the energy of adhesion of thin films on inert substrates. The thin film breaks up into an array of beads or islands on heating to well below the melting point. The energy of adhesion can then be deduced from the shape of the equilibrated beads, which can be viewed on a SEM. The method has been applied to Cu films on Al<sub>2</sub>O<sub>3</sub> to follow the change of adhesion with ion bombardment. The Cu films up to 20 nm thick are deposited on different crystal faces of sapphire. The researchers found that orientation of the substrate had little effect on the energy of adhesion though the nature of the bombarding ion had a pronounced effect. Bombarding by He (100 keV) ions had little

or no effect on the beading while Ne (100 keV) changed the beading characteristic completely.

D.B. Poker, J. Schubert, A. Alexandrov, J. Fröhlingsdorf, and B. Stritzker (Institute für Festkörperforschung, Jülich, West Germany) reported on the remarkably enhanced adhesion of Sn film, 100 nm thick, to glass or quartz substrates following low-temperature implantation of H or He (20 keV) ions at fluence up to  $3 \times 10^{16}$  ions/cm<sup>2</sup> at liquid nitrogen temperatures. Moreover, they observed the growth of whiskers of Sn as it warmed slowly to room temperature after the irradiation.

#### Ion Projection Lithography

An important development in lithography for the semiconductor industry was presented by H. Löschner and G. Stengl (Ion Microfabrication Systems, Vienna, Austria). They described a complete system of lithography based on the demagnified projection of an ion beam. They used a 1:10 reduction through an open stencil mask. (However, the semiconductor industry has a tradition of not liking stencil masks.) A resolution is attainable of 100 nm with a large depth of focus greater than 100  $\mu$ m. They constructed a complete alignment system using electronic rather than mechanical alignment procedures. This whole lithographic system has some very interesting potentials for use in the submicron range.

#### Some Active Laboratories

Representatives from some active research laboratories that may be less well known presented many interesting papers.

The Central Research Institute, Budapest, Hungary, was well represented by a series of papers given by E. Jaroli, M. Fried, T. Lohner, C. Hajov, and E. Kotai. Their papers covered a wide range of studies of the damaged surface layer of Si and Ge after implantation. They determined the optical properties, refractive index, and extinction coefficient of the amorphous state of Si, and they have shown that ellipsometry can provide an alternative method of estimating the damage layer thickness. They also modeled the mechanical stresses induced by ion implantation. Adhesion problems of contact materials, such as Au alloys on GaAs, were overcome by the use of ion beam mixing by 700 keV noble gas ions.

Another laboratory represented by a very impressive series of papers was the Laboratoire de Métallurgie Physique, Poitiers, France. J.P. Villain, R.J. Gaboriaud, J.P. Eymerly, C. Jaouen, J.C. Desoyer, and others presented papers on a wide range of topics. Rare gas clusters

formed by ion implantation in Al, Fe, Ni, Au, Zn, and Si were shown by TEM to consist of small crystalline precipitates epitaxially aligned with the metallic matrix. Xenon implantation at room temperature for Al and at 350°C for Si give rise to solid face-centered cubic Xe clusters. These solid clusters have been studied at temperatures up to 750°C when the transition to gas bubbles occurred, the phase change being reversible. Excellent studies by TEM, electron diffraction, SIMS, and RBS have been used to follow these changes and to follow the changes in the stress characteristics around the clusters.

Villain et al. have also studied (by TEM, SIMS, and RBS) the behavior of TiN coatings, widely employed to improve wear and corrosion resistance and as a potential diffusion barrier in microelectronics. Ion beam mixing reactions, induced by a Xe ion beam, were employed to study TiN coatings on Al and on Ni: markedly improved wear resistance resulted. It appears that the wear resistance is related to the presence of a surface amorphous phase and that as the amorphous layer recrystallizes, the wear resistance decreases.

A very elegant and fascinating talk was given by Dr. W.L. Brown (AT&T Laboratory, New Jersey) on radiative and non-radiative processes associated with the excitations induced by MeV light ion bombardment. Solid argon was taken as the model system and the irradiation facility involved a UV spectrometer and a quadrupole mass spectrometer. The system permitted the simultaneous observation of luminescence and sputtering behavior.

#### Commercial Applications

Current commercial applications of ion implantation in the field of biomaterials (hip joints, surgical appliances) were described by P. Shioshansi (Spire Corporation, Bedford, Massachusetts). They use Fe-Cr-V, Ti-Al-V alloys and also some polyethylene components irradiated by N ions. The effect of the N ion implantation has been to increase the wear-resistant properties. A whole range of industrial applications are offered by UNIREC, France, of steel tools irradiated by N (100 keV) ions. Many of these tools have an order-of-magnitude longer service lifetime than nonirradiated tools.

#### Conclusion

Real improvements were reported to the surface wear properties of many materials modified by ion beam implantation to the extent that many products are now commercially available. These stem from the availability of implanters designed

for semiconductor work, usually at energies of the order of 100 keV. Many studies presented at this conference seemed to have been carried out on the same material (steels) with the same ion (typically N) and at the same energies. There should be advantages in going to higher energies ( $\sim$ MeV), though only a few of the studies used this energy range.

There were several reported observations of the bombarding ion penetrating much deeper than expected and that the improvement to surface properties of the material in these cases persists to much deeper depths than expected even as material is worn away from the surface layer. This phenomenon is worthy of very careful study.

The mechanism of improved or changed surface properties has not been sufficiently examined to give clear descriptions of the effects. Subsurface dense dislocation networks are reported in some cases (e.g., WC), cluster formation in other compounds (e.g., garnets), and amorphous zones at or below the surface in still other cases (e.g., diamonds). In particular, the formation of the amorphous material needs to be studied further as well as its properties and annealing characteristics since it is not clearly demonstrated whether the amorphous conditions reported correspond to a noncrystalline state.

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8/15/86

#### TRIBOLOGY RESEARCH AT THE METAL RESEARCH INSTITUTE OF TNO

by Irwin L. Singer. Dr. Singer is head of the Tribology Section in the Chemistry Division at NRL. He was at the Metallurgy Department of Cambridge University, England, on sabbatical leave until September 1986.

If you ask A.W.J. de Gee "How wear resistant is steel?" he'll no doubt say, "That depends." And he's not trying to be divisive. Over the past 15 to 20 years, he and many tribologists around

the world have come to appreciate that wear is not a material property; rather, it is a property of a system whose components, environments, and interactions contribute to bring about (or protect against) failure of materials in moving contact. Nonetheless, de Gee's responsibility at the Metal Research Institute of the Netherlands TNO, in Apeldoorn, is to select materials--solids or liquids--for tribological applications. My aim in visiting de Gee was to learn the methods he is using to evaluate the tribological behavior of a variety of practical materials, ranging from lubricant additives and surface treatments for steels to non-metals like polymers, and the system's parameters which are most likely to control the friction and wear processes.

TNO--The Netherlands Organization for Applied Scientific Research--is a nonprofit research and development organization established in 1930. (For detailed information on TNO's organization, policy, and funding see ESN 38-8:438-440 [1984].) Its 5000 staff members perform research ranging from industrial projects for individual companies to basic research financed by the Dutch government. TNO has two groups working in tribology--the study of friction, wear, and lubrication. One group in Delft concentrates on mechanical design aspects of bearings, gears, and related devices. The other group, in the Metal Research Institute at Apeldoorn, specializes in materials problems, with particular emphasis on the tribological interactions between materials, lubricants, and environments.

### Philosophy

Tribology research at Apeldoorn has always emphasized the role of tribometry in the selection of materials for tribological applications. "We always try to learn as much as possible about the function of a machine's triboelement, whether it be a cam, gear, bearing, etc... Only then do we select, or if necessary, develop a tribometer adapted to the function of the machine." De Gee, therefore, is not interested in standardized wear testers. "A tribometer (i.e., a laboratory-scale testing device) should be chosen to simulate the contact conditions and type of motion that would be found in practice." He is, however, interested in standardizing wear testing methods, and the Metal Research Institute sells a multipurpose tribometer designed to control the most important variables applicable to a particular test.

From years of experience, de Gee and his colleagues A. Begelinger and G. Salomon (now deceased) came to regard three variables of the tribosystem as most in

need of controlling and understanding: load, speed, and temperature. These variables play an important role in the lubricated sliding wear behavior of metals whose contact zone concentrates the stresses to a point or a line. The investigations that have led to present-day understanding of the failure mechanisms in lubricated wear processes began over 15 years ago as a multinational cooperation established under the banner of the *International Research Group (IRG) on Wear of Engineering Materials*. From this effort came, amongst other concepts, the systems approach to analyzing problems in tribology and the transition diagrams to be discussed below.

### Load-Carrying Capacities of Concentrated Contacts in Lubricated Sliding

The Transition Diagram. The wear behavior of metals in concentrated (non-conforming) contact under lubricated sliding conditions can be mapped out by a transition diagram, which plots the normal force  $F_N$  vs. sliding speed at a given oil bath temperature. A typical transition diagram, obtained for hardened steels in the ball vs. cylinder contact geometry, is illustrated schematically in Figure 1. One sees three regions of different wear behavior, separated by two "transition" curves. In region I, wear is usually invisible to the naked eye on the cylindrical surface and only a small contact spot can be seen on the ball. In region II, a visible oxide layer forms on the cylinder and a correspondingly large spot is worn on the ball. In region III, the wear scars and debris layers on both surfaces are huge by comparison with regions I and II. It is believed that the specimens run virtually unlubricated, despite being fully submerged in the lubricant. Although discussed here for the ball vs. cylinder contact, the transition diagram has been found to apply in most common geometries (e.g., 4-ball, crossed cylinders, ball vs. flat) used to study the wear of concentrated contacts.

Regions I, II, and III can also be distinguished by friction vs. time curves, which also correlate with the wear behavior. In region I, the friction coefficient briefly jumps to 0.3, then within a second, drops to a steady-state value between 0.05 and 0.1. Very high wear rates occur during the brief high-friction period, followed by much lower and steadily decreasing wear rates, often resulting in acceptably low wear. In region II, the friction coefficient jumps to 0.3, remains there for 5 to 10 seconds, then falls to a steady-state value near 0.1. This initial friction plateau results in a factor of about 10 or so

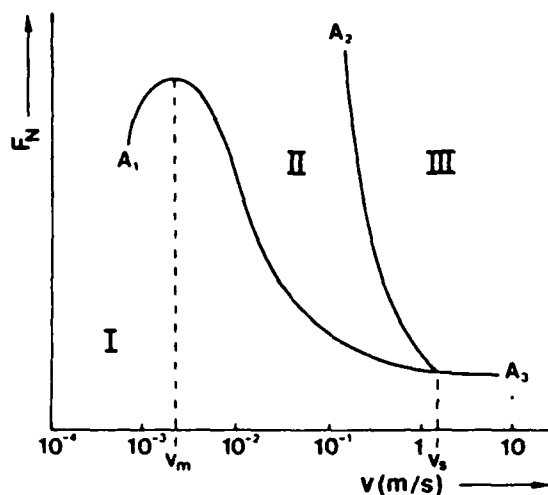


Figure 1. The transition diagram for ball-cylinder contacts at constant oil bath temperature (schematic): I, regime of (partial) elastohydrodynamic (EHD) lubrication; II, regime of boundary lubrication; III, regime of virtually unlubricated contact ("scuffing regime").

greater wear than in the initial wear in region I. Subsequent wear rates are also low and, as in region I, eventually fall to zero. In region III, the friction coefficient jumps to 0.4 and remains there throughout the test; wear is severe, the wear rate being high and constant. Hence, friction behavior not only affects wear, but also provides an easily identifiable signature for the three wear regions.

The main factors which influence the load carrying capacity (i.e., the location of the various transition curves) have been identified. The lower transition curve ( $A_1A_3$ ) decreases as the initial surface roughness increases, and increases as the lubricant viscosity increases. The oxygen content and the chemistry of the lubricant are also important, whereas the metallurgical nature of the surface is of secondary importance. The upper transition curve ( $A_2A_3$ ) depends mainly on the metallurgy of the surfaces and the chemistry of the lubricant. These transitions are usually quite abrupt, occurring with load changes of several Newtons.

**Failure mechanisms.** A model which explains these experimental results has been examined and developed by de Gee, Begelinger, and Salomon. They assume that in region I a condition of partial elastohydrodynamic lubrication prevails. Friction and wear behavior are attributed to initial asperity (i.e., surface high

point) wear, followed by oxidation or other chemical reactions, giving way to virtually no wear as the earlier mild wear processes tend to drive the two surfaces into conformity. The "no wear" condition is obtained when elastohydrodynamic (EHD) conditions are established. (Elastohydrodynamic lubrication indicates that the fluid behaves like an elastic solid capable of transmitting pressure and carrying loads.) The rise in the lower transition curve at low speeds can be explained by the hydrodynamic wedge effect, known to increase the load carrying capacity. The transition to regions II and III results from collapse of liquid film lubrication. At speeds above  $V_m$ , frictional heating of the fluid in the contact zone reduces the viscosity and therefore the load carrying capacity of the EHD film.

If collapse of the EHD film occurs at  $V < V_x$ , then the two surfaces come into contact, resulting in high friction and sustained mild wear. Region II may thus be identified as boundary lubrication. Gradually, the load bearing area increases, EHD conditions are reestablished and the wear rate goes to zero. If collapse of the EHD film occurs at  $V > V_s$ , the temperature at the junction rises above the critical temperature at which boundary lubrication fails, and scuffing (region III) ensues. The transition from region II to region III at low speeds is also due to failure of boundary lubrication, but not because of lubricant failure. Rather, the transition to scuffing is dependent on the metallurgical stability of the surfaces during the initially high friction contact, where temperatures can easily reach 400 to 500°C. These temperature-sensitive transitions have been studied both experimentally and theoretically (Blok-Archard models), and are in good agreement with the behavior of the transition diagram.

**Application to Lubricants.** Transition diagrams were obtained for a purified oil containing five additives known to improve the wear performance of steels. Two of the additives, TCP and stearic acid, significantly increased the first transition curve, while two other additives, DBDS and ZDDP, greatly increased the second transition curve. (Interestingly, TCP actually lowered the "scuffing" transition.) TCP and stearic acid promoted partial EHD films at high loads by reducing friction-generated heating of the films, while DBDS and ZDDP resisted scuffing by reducing friction-generated degradation of the surfaces. These tests also illustrate the folly of attempting to establish the intrinsic wear-abating behavior of additives without reference to specific load, speed,

and temperature conditions. For example, at moderate loads, TCP promoted EHD lubrication but DBDS did not; hence, TCP would be considered a "good" additive. By contrast, at twice the load, TCP-doped lubricants led to scuffing whereas DBDS-doped lubricants produced only mild wear.

Application to Coatings. TiN- and TiC-coated steel balls had significantly higher load carrying capacity than uncoated steels. Interestingly, comparisons of coated vs. coated and coated vs. uncoated curves showed that one coated surface provides more protection than two coated surfaces. Surface treatments may also reduce wear, as was the case of salt-bath nitriding of steel, which eliminated scuffing in regime III.

In summary, transition diagrams identify the loads dividing fluid film lubrication from stable (boundary lubrication) or unstable (scuffing) wear conditions as a function of speed and oil temperature. As illustrated in the above two examples, these diagrams make it possible to characterize novel materials, surface treatments, and lubricants for application in which concentrated contacts prevail. And, of great importance at TNO, they have been shown to predict reasonably well the wear behavior of many tribocomponents such as cams and tappets, worm gears, etc. operating in unidirectional sliding.

#### Friction and Wear Behavior of Polymeric Materials

A second example where the systems approach is leading to simple, reliable tribotesting is for polymeric materials. It was recognized early on that polymers, even more so than metals, degrade because of heat buildup at the frictional interface. Polymers, in fact, pose special materials problems in that their thermomechanical behavior is often more closely related to the manufacturing history than to the chemical formula. Therefore, there was a great need for a quick and reliable test method capable of predicting the friction and wear behavior of materials at any speed or velocity. In the 1970's, TNO developed a tribotest method that was capable of explaining what happens to brake lining materials (polymeric composites) brought in contact with mating metal surfaces at a fixed temperature. Isothermal conditions during friction and wear measurements were assured by making periodic contact lasting only seconds. Unfortunately, the tests were very time consuming, so they could not be relied on to provide data for all temperatures; moreover, they could not answer the practical question of how a given material behaves after repeated thermal cycling under stress.

Recently an improved test method has been devised by de Gee and his colleagues. They call it a pseudoisothermal friction and wear test. Friction coefficient and pin wear measurements are recorded during (relatively) low-speed sliding while the temperature is increased from near room temperature to some maximum (e.g., service limit) temperature. Friction vs. temperature and wear vs. temperature curves, so obtained, give signatures of the friction and wear behavior of the materials. These curves, for selected materials, have been shown to contain all the information needed to predict the friction vs. temperature behavior at higher sliding velocities or the friction vs. velocity behavior at higher temperatures.

The testing, however, is neither simple nor routine. A tribotester had to be engineered to be sensitive to the viscoelastic properties of polymers. Polymers, more so than metals or ceramics, are sensitive to vibrations and sample eccentricity. Also, pin wear measurements required special calibration procedures in order to account for the thermal expansion of the viscoelastic pin under stress. The difference between the pin "wear" measurements in static ( $V=0$ ) and dynamic (at test speed) pseudoisothermal tests gave the true pin wear.

This method was first demonstrated on a series of friction materials, brake liners (Honselaar and de Gee, 1985). The curves yielded a 'fingerprint' for each of the brake liners, characteristic of their composition and structure, which could be used for identification purposes and acceptance testing. In evaluating the performance of brake liners, it is also necessary to characterize the friction and wear behavior of materials subjected to repeated contact at high service temperatures. Curves obtained after repeated runs showed great variability, depending, in particular, on the maximum temperature. However, analysis of these curves and of the material transferred to the metal counterface gave a fairly accurate picture of the in-service performance of brake liner materials.

More recent studies have confirmed that the pseudoisothermal test method is also a fast and reliable method for assessing the friction and wear vs. temperature behavior of antifriction polymers, such as polyimides, used in high-temperature applications (Uppsala University, 1986). In these studies, the pseudoisothermal curves obtained at slow sliding speeds ( $V=0.01$  m/s) gave the same friction vs. temperature curves measured at higher sliding speeds ( $V=0.3$  m/s), after adjusting for a velocity-dependent interfacial temperature. This temperature

averaged about 30°C higher than the value measured by a thermocouple buried within a millimeter of the polymer interface, with variations from 10 to 80°C, depending on the amount of film transferred during sliding. As happened in the IRG transition diagram studies, a great number of tests will be needed to decide on the range of applicability of the pseudo-isothermal test method for polymeric materials.

#### Summary and Conclusions

The value of the mix of applied and basic research is apparent in the work at TNO. Much of the early data that led to the transition diagram model was obtained studying real-world industrial problems by trial and error, relying on feedback from suppliers of lubricants or alloys. With increasing confidence came more detailed investigations of the failure mechanisms of thin lubricating thin films. In the 1970's, when more than half of the group's funding came from the government with "no stings attached," there was ample incentive to tackle these fundamental issues. Today, with government support at the 10 percent level and industrial support at 70 percent, quick answers often override sustained scientific efforts.

The changing funding pattern has also brought on new roles for de Gee and the tribology group. In the 1970's, with a staff of 22 engineers and scientists, the group could and did provide the know-how, equipment, and manpower to assist industrial firms like Phillips build their own tribology groups. Today, with many more tribologists competing for fewer dollars, TNO's four remaining tribologists are hard pressed to carry on applied and basic research by themselves at previous levels. It is de Gee's hope, however, that future applied tribology research in the Netherlands will be carried out by a consortium made up of TNO and the Dutch technical universities (where he teaches part time).

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## Mechanics

### EUROPEAN TURBULENCE CONFERENCE

by Eugene F. Brown. Dr. Brown is the *Liaison Scientist for Fluid Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office*. He is on leave until September 1987, from the *Virginia Polytechnic Institute and State University*, where he is a *Professor of Mechanical Engineering*.

The European Turbulence Conference was held from 1 through 4 July at the *École Central de Lyon (ECL)* in Lyon, France. This was the first of a series of conferences which are planned to take place every 2 years. Future conferences are intended to specialize in subjects such as reacting flows, combustion, two-phase media, aero/hydroacoustics, and flow/structure interactions. In this meeting there were papers and keynote review lectures in the areas of:

- Chaotic behavior of nonlinear systems
- Instability and transition
- Geo- and astrophysical aspects of turbulence
- Large eddy simulation
- Coherent structures

In addition to the oral presentations, five poster sessions were presented in the areas of:

- Chaos and transition
- Numerical simulation
- Geo- and astrophysical turbulence
- Coherent structures
- Experimental techniques

Approximately 160 engineers, physicists, and mathematicians were in attendance, with approximately one third of the attendees from France and large numbers from the UK and West Germany. There were several attendees from Eastern Block countries and from the US.

The meeting was held under the auspices of the European Mechanics Committee (EUROMECH), which has been organizing conferences in the fluid and solid mechanics areas since 1964. In his opening remarks, Professor G.K. Batchelor of the University of Cambridge, the current EUROMECH chairman, said that EUROMECH was founded in an attempt to overcome the national, cultural, and linguistic barriers between European countries by providing an international forum for



technical information exchange. This meeting was the 210th to be held since the committee was organized and represents the first meeting which has departed from a tightly focused theme. At the beginning of the meeting, a complete proceedings was distributed; it includes the abstracts of the 25 oral presentation and the description of the contents of the 59 poster presentations. Written versions of the oral presentations will be published by Springer-Verlag as a special bound volume. This should be available in 6 to 8 months.

After a review lecture on chaotic behavior of nonlinear systems and chaos via quasi-periodicity by M.P. Berge of the Commissariat à l'Energie Atomique (CEA), Saclay, France, and a related presentation by M. Dubois (also of CEA), B. Aupoix (ONERA, Toulouse, France) talked about his work related to a rationalization of the dissipation equation for the  $k$ - $\epsilon$  turbulence model. The idea was to develop a dissipation rate equation based on a simplified model of the spectral energy content of homogeneous turbulence. The procedure is called the spectral integral method (MIS). The advantage of the technique is that it is expected to be more general than Launder's empirical dissipation rate equation. Results for a number of cases show that in fact the new dissipation rate equation does better than Launder's equation and, in addition, completely avoids so-called "tuned" constants. An extension of this method is underway for inhomogeneous turbulence.

Dr. U. Schumann of the Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, West Germany, then presented a review lecture summarizing the results of last fall's EUROMECH Colloquium Number 199, Direct and Large Eddy Simulation of Turbulence, held in Munich, West Germany. I reviewed this meeting in ESN 40-3:98-102 (1986). The papers presented at this meeting will soon appear in *Notes on Numerical Fluid Mechanics*, 15, published by Vieweg-Verlag.

#### Turbulence Structure

A keynote lecture on turbulent structure was delivered by Professor H. Fiedler of the Technical University of Berlin. After defining coherent structures as "discernable correlated regions of concentrated vorticity immersed in a stochastic background," he briefly discussed experimental methods by which these structures can be visualized, including conditional averaging and pattern recognition.

Often, Fiedler said, acoustic methods are used to stabilize the structures; however, there is some evidence to show

that this produces a flow that is much too clean. As a consequence of this, the source of secondary instabilities is removed, and the intermittency of the turbulence is affected.

After briefly reviewing the evolution of coherent structures associated with transition such as streaks, bursts, and the bulges and large eddies associated with the outer flow, Fiedler talked about the manipulation of coherent turbulence structures. The benefits of such manipulation include reduced noise, enhanced mixing, higher lift, and reduced drag (although these effects are to some extent mutually exclusive). Various ways have been developed for manipulating the coherent structures including acoustic excitation, polymer addition, and special surface treatments such as riblets and large eddy breakup devices (LEBU's).

Fiedler characterized the topology of coherent turbulence structures as a veritable "zoo" consisting of a bewildering combination of basic structures such as line, ring, hairpin, and helical vortices. Given the fact that even after almost 10 years of research there is still no common agreement on what constitutes coherent structures, it is not unreasonable to question the utility of the concept. Perhaps comfort can be taken in the fact that if one wishes to predict the effect of turbulence one must first understand it, and the concept of coherent structures appears to offer the best promise of rationalizing what had before appeared to be a random collection of events. Nevertheless, Fiedler pointed out that the concept of coherent structures is useful only to the extent that it allows turbulence to be described in terms of a relatively simple collection of vortex modules. At the present time this seems possible only for a relatively simple, clean, and otherwise undisturbed flow and perhaps then only for the near-wall and near-wake regions.

#### Nonequilibrium Boundary Layers and Transition

M. Michard of ECL described a study in which an array of 100 4-cm-diameter propellers were used to produce a nonequilibrium turbulence spectrum. By using such an "active" grid, a turbulent flow was produced with a strong peak corresponding to the rotation rate of the propellers. Such singularities are often associated with the presence of coherent structures and strong inhomogeneities. To amplify the vortex field produced by the propellers, a 5:3 contraction section was used producing a 30x30-cm<sup>2</sup> test section. The test section velocity was 4.0 m/s, and the rate of rotation of the propellers was 90 Hz. The turbulence



Reynolds number was 140. A cross-wire anemometer was used to measure the components of the Reynolds stress tensor. The magnitude of the Reynolds stresses and their spectral composition was compared with a large eddy simulation (LES) calculation. Qualitative agreement with the measured results was obtained.

J. Stuart (Imperial College, London) expressed the opinion that Taylor-Couette flow and the flow in the spherical gap created by two rotating concentric spheres provided examples of dynamical systems which deserved further study. Such an investigation was described by J. Brindley (University of Leeds, UK) who studied Taylor-Couette flow at high Taylor numbers. He used a processing system employing a standard monochrome camera which allowed  $256 \times 256$  pixel digitized images at a resolution of 256 grey levels. A VAX 11/780 computer was used to obtain frequency and phase spectra information from this data at a large number of positions in the flow. In a related study of the flow in a spherical gap, K. Bühler presented a study of the non-uniqueness which is realized by different accelerations of the inner sphere. The various instabilities were visualized by small aluminum flakes, and the flow structure in the meridional plane was visualized by using a light-sheet technique. The dynamical behavior was obtained by measuring the local wall shear stress with a hot-film sensor. A new type of shear wave was discovered which was interpreted as an instability of the three-dimensional boundary layer near the outer sphere. The interaction of these shear waves leads to a wavy net in the equatorial plane which, in turn, interacts with the Stuart vortices near the poles leading to a stochastic motion growing with increasing Reynolds number toward the equator (see Figure 1). A movie was shown which illustrated the various types of instabilities and the eventual transition to turbulence.

#### Geo- and Astrophysical Turbulence

Perhaps the most far ranging lecture was given by Professor H.K. Moffatt of the University of Cambridge. His paper was devoted to geo- and astrophysical turbulence. For two-dimensional (geophysical) flows two classical theories appear to give conflicting results. These are the "vortex patch" theory which gives a  $k^{-4}$  energy spectrum and the "enstrophy cascade" theory which gives a  $k^{-3}$  spectrum. One possibility for reconciling this contradiction is to propose that when two vortex patches interact the stronger tends to wind the weaker into a tight double spiral structure whose spectrum falls off more slowly than

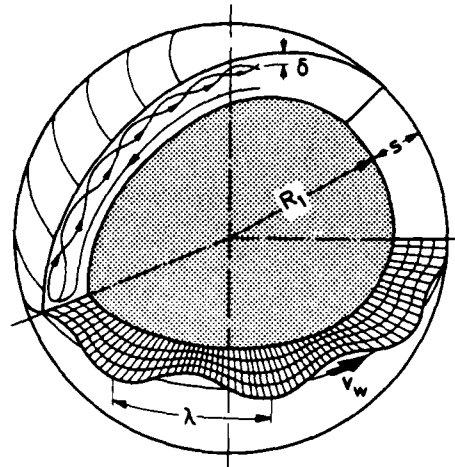


Figure 1. Shear instabilities in a spherical gap showing the flow structure in the meridional plane and the waviness of the equatorial plane.

$k^{-4}$  over a range of wave numbers. Current computations at Cambridge indicate the emergence of a  $k^{-10/3}$  range due to this effect. This same mechanism may also be of central importance for fully three-dimensional turbulence. If it is assumed that such flows can be modeled by a random distribution of vortex sheets separated by large coherent structures, a  $k^{-2}$  spectra power law results. However, because of the Kelvin-Helmholtz instability they wind up in the characteristic double spiral structures. It seems likely that the famous  $k^{-5/3}$  law may be obtained through proper understanding of those double spiral singularities which provide a transition from vortex sheets to vortex filaments embedded in the turbulent flow.

R.A. Antonia of the University of Newcastle, Australia, described his study of the topology of organized structures in a turbulent plane wake. This was an investigation of the organized motion in the far wake of a circular cylinder. Wind tunnel measurements were made for the flow over a heated cylinder. The Reynolds number based on the cylinder diameter was 1200 and measurements were taken at a distance of 420 cylinder diameters downstream. Data was taken with a span-wise rake of cold wires and a cross hot-wire/cold-wire combination. Velocity fluctuations (both longitudinal and lateral) and measurements of the temperature fluctuations were conditioned on the occurrences of spatially coherent temperature fronts detected from the cold-wire data. A triple decomposition was used in

which the velocity was divided into mean, coherent, and random fluctuations. To generate ensemble averages, about 500 detections were selected on the basis that the streamwise extent of individual temperature signatures coincided approximately with the independently determined average wavelength of the structures. A map of the velocity vectors obtained relative to an observer moving with the convection velocity of the structures exhibited a vortical pattern similar to a Kármán street in which critical points composed of centers and saddles could be clearly identified.

#### Riblets and LEBU's

D.W. Beckert of (DFVLR, Berlin) then described his work using riblets as a drag reducing device. He said that the potential of conventionally grooved surfaces was limited since only a 7 to 8 percent reduction in drag could be expected. This was because the protrusion height of such riblets (be they triangular, scalloped, or thin bladed) is only slightly more than 22 percent of their actual height. This corresponds to a penetration of only five wall units. This places the effective height of the riblets well within the laminar sublayer. Since the idea of riblets is to impede the cross flow, some way must be found to reach the vortices in the outer region of the flow. Beckert felt that a possible way to increase the protrusion height was by the use of short, staggered riblets. With the use of an electrolytic tank, he was able to show that such riblets have the potential for more than doubling the protrusion height. These results were confirmed by a theoretical analysis. It is interesting to note that such staggered riblets can be found on the skin of fast-swimming sharks.

Dr. A.M. Seville of the University of Cambridge, UK, presented his work (supported by Rolls Royce) on boundary layer manipulators, in which he studied the manner in which the outer layer disturbances affect the turbulent boundary layer skin friction. Drag reduction by these so-called large eddy breakup devices (LEBU's) has become a extremely popular research topic. In 1981 there were only four groups working in this area. In 1984 the number had grown to 24, and today there are 44 groups (according to Seville's latest count).

Seville's results showed that the friction velocity beyond 15 boundary layer thicknesses from the manipulator closely resembled that of an undisturbed boundary layer and was in good agreement with the law-of-the-wall model. Nearer the device, larger changes occur which

can be associated with the wake of the manipulator. The effect of the manipulator is to reduce the normal turbulence velocity fluctuations over a large region of the layer and produce correspondingly weaker influences on the spanwise and streamwise components. By examination of the turbulence energy spectra it was shown that the manipulator produced an enhancement of the small-scale turbulence. Various investigators have attributed the drag reduction mechanism to either immediate ("plate") effects, or to persistent ("wake") effects. Seville's study has shown that the correct explanation might in fact be a combination of these two mechanisms. For tandem manipulators he found a beating of the wakes of the two manipulators, which may at least partially explain the oscillatory behavior of skin friction as a function of manipulator spacing.

#### Conclusions

Despite the progress at this year's meeting, truly predictive methods for turbulent flows are still beyond our grasp. The lack of adequate tools to predict turbulent flows turns out to be the major pacing item in the development of a wide variety of military hardware items ranging from aircraft to gas turbines. In his closing remarks J.L. Lumley of Cornell University, New York, made it clear that direct turbulence simulation was not a reasonable attack on this problem. Using current machines and fluid mechanics algorithms thousands of years would be required to solve a problem with sufficient engineering resolution. Lumley expressed the opinion that turbulence modeling is the only hope of being able to solve such problems in the foreseeable future. The field of turbulence modeling, however, has become he said a "largely discredited occupation." Lumley called for the development of rational physical models (he believes by the method of orthogonal decomposition) to restore the field's respectability. Dr. J.C.R. Hunt of the University of Cambridge will organize the Second European Turbulence Conference, which will be held in September 1988 in Berlin. It is likely it will show the results of these and many other related activities.

8/20/86

#### FLUID MECHANICS RESEARCH AT SELECTED UNIVERSITIES IN PORTUGAL

by Daniel J. Collins. Dr. Collins is the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office

*of Naval Research's London Branch Office. He is on leave until July 1988 from the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.*

### Introduction

The principal sources of engineering graduates in Portugal have been the Instituto Superior Tecnico in Lisbon and the University of Oporto. About 50 percent of Portugal's engineering students graduate from the Instituto Superior and 25 to 30 percent from Oporto, with the rest from other universities. This distribution may change as the new educational initiatives begun in 1973 take effect. Among the new universities started at that time were Aveiro, Braga, New University of Lisbon, Evora, Corrilha, and others. In addition, a new engineering college was established at Coimbra (the University of Coimbra, established in 1290, has a long, distinguished record as a classical university).

I held discussions in the general area of fluid mechanics at the Instituto Superior Tecnico, and at the universities of Coimbra, Aveiro, and Oporto. Since I visited both the traditional engineering sources and the newly developing institutions I felt that I had obtained an excellent representative cross section of the engineering effort in fluid mechanics in Portugal.

Technological innovation is to a large extent motivated by the practical problems facing a nation and to the climate created for research by the nation's institutions. Since Portugal must import over 90 percent of its energy needs and 80 percent of this imported energy is in the form of oil, there is great interest in alternate energy sources. These alternate sources include wave energy, wind mills, and solar energy. An international conference on wave energy was recently held, in fact, in Lisbon.

Some interest in wind turbines was expressed at all the universities I visited. The effort in this area is directed at improving airfoil shapes and at the ease of manufacturing and reliability of the wind turbines. I will discuss the solar energy initiative in the section on Oporto University.

Probably the largest remaining forested areas in southern Europe are in Portugal. Since forest fires are a severe danger to this resource, there is great interest in modeling forest fires and the airflow about forests in varying terrain. Thus there is some emphasis on subsonic tunnel development to aid fire research.

Also of great interest to Portugal is water flow around rivers and barriers in irrigation projects; this has led to

basic investigations of stagnation and separation flows, in which some quite fundamental work can be found. Drag reduction of ground vehicles, another active area of research, is discussed in the section below on Coimbra University.

### Institutional Structure

Until approximately 5 years ago support was readily available for overseas graduate studies. Prior to the cutoff of this support, many of the younger research scientists and engineers (30 to 35 years old) had obtained their Ph.D.'s in the UK, France, Germany, Belgium, and, to a lesser extent, America. These international connections are still actively maintained, and quite a few fairly technical investigations are conducted jointly with, for example, researchers at Imperial College in London and Erlangen in West Germany. These arrangements overcome to some degree the shortages of what could be termed expensive modern technical equipment.

The typical graduate begins his academic career as an assistant and is expected to obtain his doctorate within 6 to 8 years. The courtesy title Professor is granted to everyone after they receive the doctorate. Each person is a civil servant in the Portuguese government. Advancement after the Ph.D. is through essentially the same levels as in America; i.e., associate and full professor. Desire for promotions generates concern in the curriculum vita and involves the necessity to publish, typically in English. The Ph.D., unlike that of the US, is strictly an academic degree and does not lead to the person's involvement in industrial activity. Thus, the system does not produce the kind of close ties with industry that the American system does.

Within the last 4 years there has been a strong government initiative to increase academic and industrial contacts. This initiative has involved grants of money to industrial concerns, with the provision that it be used to fund university research. From this there has developed what is termed by the academic people good working relationships between industry and the universities. Industrial contracts lead, in particular, to purchase of needed technical equipment and not to increases in salaries of the individual investigators.

Several national agencies fund research. The two main agencies are: Instituto Nacional de Investigacao Cientifica (INIC) and Junta Nacional de Investigacao Cientifica e Tecnologia (JNICT).

The general salary support, library, and workshop support comes from (INIC). Special projects may be funded through

JNICT, but this requires a special request or submission with extensive reviews. Other Portuguese sources of money include:

- The Gulbenkian Foundation, which may fund needed expensive equipment such as a laser Doppler anemometer.
- The Luso-America foundation, which provides funds in information technology area with first-project funding in the \$100,000 to \$300,000 level.
- The national budget for large equipment and laboratories. (National priorities were clearly evident in my visit to some of the universities.)
- EEC funding sources. With the recent entrance of Portugal into the European Community this may become an important source of technical innovation. Many of the scientists and engineers I interviewed were preparing EEC proposals because this is a new source of funding.

#### Instituto Superior Tecnico

The Technico has some 6000 students and seven campuses throughout the country. Its principal campus is located in Lisbon. The engineering program is a 5-year program analogous to that of the German diploma engineer. Dr. Brown (an ONRL colleague) and I held discussions with Dr. D.F.G. Durão (Ph.D. from University of London), who is the head of the Mechanical Engineering Department and a council director of the Technico. Approximately 1000 students study mechanical engineering; over 150 graduate each year. The department offers both a master's and a doctoral program. Durão has been chairman of the very successful series of International Symposia on Applications of Laser Anemometry to Fluid Mechanics which have been held in Lisbon every 2 years since 1982. (See page 467 for a note on the most recent one.) Durão is an international authority in laser Doppler anemometry (LDA) and has published extensively in the field of LDA. His research interests have included detailed measurements of impinging jets, turbulent flows, and separated flows (Durão 1981, 1982, 1984, 1986). Further work of his has involved velocity and amplitude bias effects, and signal quality of laser anemometry (Durão, 1985). He is presently engaged in joint research projects with Imperial College and Erlanger.

Dr. M. Nina, of the combustion and energy systems group of the Mechanical Engineering Department performs experimental measurements on flames using LDA, Kistler gauges, and thin films. His laboratory consists of a small subsonic wind tunnel, swirl can, and a combustion rig. The combustion rig was built by

money obtained from a US Air Force contract. He has had collaborative efforts with the Naval Weapons Center (China Lake), Drexel University (Philadelphia), and Imperial College (London). One of these projects involves acoustic coupling in flames (Nina 1986, 1985). He will be spending 2 weeks this summer at China Lake. One of his more interesting current projects is the application of filter optics to diagnose combustion systems. He is also proposing fundamental research in forest fires.

In general, the Technico was somewhat short of space and modern technical equipment. A new building program scheduled for completion in a couple of years should alleviate space problems. The contracts with industry may lead to purchase of more modern laboratory equipment. The computer support for the Technico appears adequate. Central computing is by means of a complex of four Vax 11/780 computers. Some IBM PC AT's were also available.

#### University of Coimbra

Coimbra has a long, distinguished history as a classical university; i.e., philosophy, law, medicine, languages, etc. Its College of Science and Technology, which has existed for only 13 or 14 years, does not yet have adequate space for the present engineering facilities. Again, one expects that the construction of a new engineering campus, to be done within about 3 years, will improve space problems and, perhaps, also further equip the laboratory.

My visit here was primarily with the people associated with the Center for Mechanics of Fluids, which is directed by Dr. D.X.F.C. Viegas. Viegas heads a young group of five active researchers who are working on problems directly applicable to national goals. Thus they have done, or are beginning, work on forest fire modeling, vehicle drag reduction, and wind turbines. The facilities available to them include a small supersonic tunnel, a subsonic tunnel with a three-component balance, and a large, open-loop subsonic tunnel. They are conducting some fundamental natural convection studies in the subsonic tunnel. LDA investigation by Dr. L.A.S. Oliveria (Oliveria 1984) of entrainment between two rotating disks is also of interest. There is a strong connection with the University of Poitiers in France in that three people associated with the group have studied there.

The work of Dr. J. Campos of the Center of Thermodynamics includes combustion, explosion studies, and explosives. His group is studying shock waves

in powders, and developing plastic and emulsified explosives. Explosives are of great industrial interest and, perhaps because of this, a variety of more modern equipment was present in the laboratory. This included an IBM PC AT for data processing and fast oscilloscopes.

The computer facilities were generally inadequate for modern engineering studies, but there is a plan to institute a national computer net in Portugal; this should improve the situation.

#### University of Aveiro

Since Aveiro is one of the new universities the space facilities are reasonably adequate, with people and laboratories housed in new buildings. The student body numbers 2500 and will shortly go to 7000. My host for this visit was Professor C. Borrego of the Environmental Science Department, which is the newest department to be established at Aveiro. It has 21 professors and assistants. Although present emphasis is on obtaining the Ph.D. in Portugal, two members of the department are in the process of obtaining theirs in England and another is obtaining his in the US. The work in the US is at the University of Illinois and involves flow and heat transfer in three-dimensional ducts with bifurcation using numerical analysis and LDA measurements.

The state supports the basic operation of the university but, again, modern equipment comes principally from other sources. Thus the Gulbenkian foundation has supplied money for the purchase of a new LDA system.

The Environmental Sciences Department is actively involved with local industries, principally in the area of environmental quality and pollution. They have investigations involving the dispersion of air pollution by the chemical industry, north of Aveiro, and stream pollution by the paper industry. Papers on these subjects have been presented at international conferences (Borrego 1981, 1984; Pio, 1986). Borrego has made LDA measurements of concentration/velocity in the mixing layer of two-plume streams and has also made LDA measurements at Von Karman Institute in Belgium.

In an interesting short visit to other departments (principally the Physics, Electronics, and Telecommunications Departments) I obtained a good comparison of what I believe are national priorities. The Electronics and Telecommunication Department are well-supported with computer facilities. Their main computer, which will soon be updated, is a Nova computer. There is also a microvax available to students in the research laboratory. The department is heavily involved

in pattern recognition and image processing with particular reference to medical research (e.g., electrocardiograms). There were also several IBM PC XT/AT computers in the laboratory. It was a pleasure visiting this modern laboratory.

#### University of Oporto

With 4000 students, Oporto is the second-largest university in Portugal. About 25 to 30 percent of the students are in the engineering curriculum. The present great need for more academic space will soon be relieved--the new building, which will be ready in 1987, should improve things dramatically. Modern experimental equipment is also at present in short supply.

My host, Dr. A. Restivo, of the Mechanical Engineering Department, has publications in the area of separated flows--studies which have been effected in a water channel and involved LDA (Restivo, 1986). The department has an extensive program on the development of light, practical airfoils for wind turbines and, in fact, manufactures its own light airfoils for wind turbines. The hydraulic laboratory was originally equipped when the building was constructed in 1970; it is essentially for instructional purposes and would profit by upgrading. This laboratory's Dr. Barros has conducted experiments using LDA on submerged gate flows. This was a joint program with the University of Erlangen-Nurnberg.

Since many of the private enterprise companies in Portugal are located around Oporto there is good opportunity for academic-industrial relationships. Such relationships exist, and the Mechanical Engineering Department has six relatively large contracts with industry. One of these contracts involves wind machines; the others concern energy systems, pollution, and environmental factors. Some joint programs are also conducted with the University of Aveiro.

Computer facilities at Oporto are better than those at Coimbra and Aveiro but not as good as those at the Tecnico in Lisbon. The department has a Wang computer, six terminals connected to a cyber 170, and a MV 8000 with 1-megabit core and 140-megabit disc storage. The facility also has a Tektronix 4109 available for CAD/CAM work.

Oporto's demonstration solar house is clearly a national technology demonstration. The house is fully instrumented for temperature and humidity measurements. Data reduction is by means of a HP 9816 with A/D converters and graphical display of all data over a floor plan of the house. I was quite impressed with

the experimental setup and do not know how one could improve it.

### Conclusion

Fluid mechanics research in Portugal is directed to wind machines, wave energy generators, fire research, and vehicle drag. Facilities are, in general, minimal, and what facilities there are are forced into small areas, but all this is in process of correction.

The people involved in fluid mechanics research at the full professor and associate professor levels have normally obtained their Ph.D.'s from excellent schools in the UK, France, West Germany, or the US. The typical young researcher has sound knowledge of his field and publishes reasonably extensively in English in journals and conferences. He is aware of the handicaps that he is working under and is fully acquainted with modern experimental methods (LDA) and numerical methods (Teach code).

It is surprising that more emphasis has not been placed in the area of computational fluid mechanics. A large computer network would have a synergistic effect on all sciences and would be a definite national asset. The main deficiency that I perceived in the resources available to fluid mechanics research was computer facilities both in terms of a main frame and minicomputers.

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8/15/86

## Ocean Sciences

### COLUMBUS OCEAN WORKSHOP

by Jerome Williams. Professor Williams is the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until December 1987 from the U.S. Naval Academy, where he is Associate Chairman of the Oceanography Department.

The UK's Southampton University hosted the Columbus Ocean Workshop on 14 and 15 July at which about 90 UK ocean scientists gathered to develop a consensus as to what oceanography-related sensors should be flown aboard the Columbus portion of the Polar Platform. The

unmanned but serviceable polar platform will orbit synchronistically with NASA's space platform and will be serviceable by means of a manned free flyer based on NASA's platform.

Columbus reflects a shift of accent from communications-type satellites to earth observation satellites, with primary useage of data for scientific research and operational forecasts, both meteorological and oceanographic. The commercial uses are envisioned to be quite small in the beginning, although it is hoped this will change with further system development.

#### Studies to be Supported

J. Woods (National Environment Research Council) attempted to bring the Columbus program into perspective by describing his idea of what scientific programs Columbus data could enhance. The concept here is that the Columbus program can be used as an adjunct to major scientific programs that will acquire data from other sources as well. Woods described programs that use models to describe climatic, anthropogenic, and natural processes including both regional and global budgets. Examples include the global carbon cycle and the biological, chemical, and geological aspects of the ocean. More specifically, a global ocean euphotic zone study has been proposed and this study would be aided immeasurably by data acquired by Columbus. Modeling exercises in the physics of the euphotic zone, the air-sea gas exchange, and the biogeochemical processes of the ocean-atmosphere system are areas of study that cannot be properly completed without the types of data obtainable only from an orbiting platform.

In addition to these oceanic-atmospheric studies it is obvious that meteorological data are necessary to develop global weather and climate models. With these meteorological data, including those representative of processes at the air-sea interface, it will be possible to gain a better understanding of weather prediction, surface wave prediction, tide surge, and tropical storms.

Some peripheral benefits include the development of space hardware and the associated maintenance of the British space industry; the development of data handling systems, including processors; improvement of various marine operations; and a plethora of social benefits that are difficult enough to itemize, let alone quantify.

Following the presentation of this background information was a series of four workshops whose purpose was to delineate the sensor types to be placed upon the polar platform.

#### Ocean Roughness

The first workshop concerned the measurement of ocean roughness. G. Keyte and B. Barber (Royal Aircraft Establishment), R. Cordey (GEC Research, Ltd.), T. Guymar (Institute of Oceanographic Sciences), and J. Scott (Admiralty Research Establishment) all provided input into possible sensors to be used in ocean roughness measurements.

The scatterometer was the first of the devices to be discussed, and that involved discussion also of some of the theory to verify the measurements. The scatterometer seems to be a very popular instrument, and the theory is reasonably well understood. The major problem suffered by scatterometer measurements is that rainfall apparently has a large effect on the accuracy of the data.

Synthetic aperture radar (SAR) was also discussed as a possible device to be used as a measure of ocean roughness. This provoked a great deal of discussion because it is apparent that the theoreticians are in complete disarray with respect to SAR. There is very little known about the relationship of the return signal from a SAR to the actual dynamics of the ocean's surface that it is supposed to represent. Sun-glint photographs also indicate oceanic roughness, but once more there is a great deal of speculation as to how one goes about transferring qualitative sun-glint pictures into quantitative data such as wind speed and direction. Passive microwave sensors were also mentioned as possible contenders for measurement of surface roughness.

#### Ocean Color

The second workshop addressed the area of ocean color measurement. J. Aiken (Institute for Marine Environmental Research) and I. Robinson (University of Southampton) discussed problems involved in ocean color measurement and some of the reasons why interest is high in this area. The primary problem is that clouds completely obscure the measurements, making it difficult to obtain any data at all in some areas. However, most UK oceanography departments and institutes have an active interest in ocean color analysis and have people who either are actively engaged in this work or are in the process of becoming engaged. Two possible sensors, or sensor types, were suggested: one for global basin work, with a resolution of about 500 meters; and the other for estuarine and coastal work, having a resolution around 30 meters. Newer sensors mentioned included the spectroradiometer, laser systems, and fluorometric sensors.



### Ocean Topography

Ocean topography was the topic of the third workshop, which included presentations by D. Webb and P. Woodworth (Institute of Oceanographic Sciences), R. Holdaway (Rutherford, Appleton Laboratories), H. Griffiths (University College, London), and L. Wyatt (University of Birmingham). The major portion of the discussion in this workshop revolved about the altimeter because there was general agreement that present working altimeters do a good job and produce data that are well understood. The big problem here seems to be that the earth's geoid is not known to an accuracy sufficient to allow useage of single-beam altimeter data for the determination of sea surface slope. Multiple-beam altimeters have been suggested to measure slope directly, as have interferometric altimeters. These two latter types of altimeters are new and consequently have not been tested from a satellite platform as yet.

Measurement of ocean surface currents directly by using HF radar in a Doppler measurement mode was discussed with the conclusion that this simply will not work aboard an orbiting system because the antenna size associated with these frequencies is inordinately large. However, there is a distinct possibility that SAR data may be analyzed in such a manner as to provide the component of surface motion in the direction of platform movement, with very little additional analysis effort.

### Sea Surface Temperature

The last of the parameter workshops addressing possible measurements from an orbiting platform was devoted to sea surface temperature (SST). Here, there was universal agreement that instruments are available which do a reasonably good job. The advanced very high resolution radiometer (AVHRR), the along track scanning radiometer (ATSR), and the multichannel sea surface temperature (MCSST) device were considered to be accurate and dependable units. Even though it is common knowledge that an error of up to .05°C may result from the difference between skin temperature and the bulk fluid temperature, the large amount of experience in using radiometers for SST measurements is a strong impetus to continue using them.

### Data Analysis

One of the big problems in the use of orbiting sensors is data handling, since so much data is produced. D. Sloggett (Software Sciences Ltd.) described the type of data analysis system that is being developed at the present time. His belief that there is no point in setting

up a data analysis and archiving center if the data will not be used seemed to be accepted by all participants. The data center concept that he outlined would make it easy to get data in any number of different ways, including via terminals scattered through the country, and by phone connection to personal computers. Data would be available inexpensively and quickly in just about any form convenient to the user, such as disk, tape, or hard copy. The UK has a goodly amount of experience in data handling, and even now is building a data center designed to process data from the European satellite, ERS-1, scheduled to fly within the next few years. This satellite will have SAR aboard, so large volumes of data will be processed. It is an easy step to move from this advanced data complex to a data center capable of handling the even larger quantities of data expected from the Columbus platform.

### Preparatory Program

One other important aspect of the Columbus program was considered: the preparatory program necessary to make sure the scientific complex is ready to receive Columbus data and utilize it effectively when it becomes available. I. Robinson (Southampton University) and T. Guymier (Institute of Oceanographic Sciences) specifically addressed this problem. Work that apparently needs to be done includes:

1. The atmospheric correction for ocean color sensors needs to be improved.
2. Additional optical measurement capability needs to be developed.
3. There need to be coordinated programs involving *in situ* optical measurements in conjunction with airborne remote sensor measurements.
4. Calibration algorithms need to be improved for all sensors.
5. There should be some effort at developing commercial applications for these data.
6. The general calibration-validation routine must be developed and refined.
7. The effects of rain must be better understood.

With the basic components of a preparatory program pretty well in hand, a recommendation was made to set up a study group taxed with defining and implementing such a program and having it funded by allocating some of the Columbus program money (10 percent was suggested) for this effort.

### Suggested Sensors

With presentation of background information complete, there was a great



deal of discussion as to which sensors should be put aboard the orbiting platform. Everyone agreed on some sort of an IR or microwave sensor for sea surface temperature, and the wind scatterometer met no objections. The advanced altimeter and advanced synthetic aperture radar concepts did not fare so well, however. There was a strong feeling against recommending a very costly instrument which might be put on the platform at the expense of more desirable, less costly instruments. Generally speaking the types of sensors suggested for placement on the Columbus platform, along with the projected use of acquired data, were strongly influenced by previous successful ventures. The sensors which had the most support were those already flown on other satellites and had produced reliable data. There was a strong feeling against untried sensors or measurement concepts. I got the impression that the final decision as to what sensors to fly would be made by a small committee, which would follow as well as it could the tenor of the group as a whole.

#### Summary

A large portion of the ocean-remote-sensing community was able to get together and formulate plans for participation in the upcoming Columbus Project. Based on previous experience, recommendations were made to delineate the nature of the project and develop the infrastructure necessary to support it. I believe the program is reasonably well thought out and has the possibility of producing some exciting results. Although the ocean-remote-sensing community in the UK is very small, I hope it is large enough (or will become large enough) to support a program as ambitious as Columbus.

8/15/86

#### EARSEL SYMPOSIUM

by Jerome Williams.

During the period from 25 through 29 June, the European Association of Remote Sensing Laboratories (EARSEL), in conjunction with the European Space Agency (ESA), held a symposium celebrating EARSEL's tenth anniversary. Entitled "Europe from Space," the symposium was held at the Technical University of Denmark in Lyngby, a suburb of Copenhagen. The aims of the conference were quite broad and were listed in the program as follows:

1. To review and discuss the use of satellite remote sensing for inventory, mapping, and monitoring of Europe, including its atmosphere, coastal and inland waters, and land areas.

2. To consider the economic and scientific benefits of European satellite remote sensing, with special reference to the user community.

3. To review European programs for the acquisition and use of satellite remote sensing data and to discuss future needs and developments.

As might be expected from this statement of aims, the program was quite diverse, but there were a number of presentations devoted to marine applications of satellite data, and it is these presentations I shall address. The first portion of the program was devoted to reporting on various uses of satellite data that have proved successful over the years, while the second portion was devoted to plans for the future.

#### Remote Sensing Results

The European Geostationary Satellite (METEOSAT) monitors the earth atmosphere system at half-hour intervals with an imaging radiometer active in three bands: 0.5 to 0.9  $\mu\text{m}$ , 5.7 to 7.1  $\mu\text{m}$ , and 10.5 to 12.5  $\mu\text{m}$ . The use of the data from these three channels was discussed by J. Schmetz and O. Turpeinen (European Space Operations Center, West Germany). With the data from these three channels the users have been able to calculate upper tropospheric winds by the use of cloud travel times; perform cloud analyses; determine the height of various cloud types; and measure sea surface temperature, upper tropospheric humidity, and precipitation index. In addition, they collected a large data set of various climatic conditions. Schmetz and Turpeinen spent most of their time discussing the problems associated with the determination of these various parameters. The sea surface temperature utilizing the IR window between 10.5 and 12.5  $\mu\text{m}$  seemed to be the one they had most confidence in due to the large number of ground truth observations to support the IR readings. Water vapor in the atmospheric column was determined from the 5.7- to 7.1- $\mu\text{m}$  channel, but there was not quite as much confidence in these values. In addition, the atmospheric corrections used were based on standard aerosol distributions, an assumption which is somewhat in doubt. Another area of uncertainty concerned the analysis of upper tropospheric winds from cloud tracking. There seemed to be better agreement between satellite determinations and cloud motion at lower levels than at upper levels. Whether

this was due to clouds dissipating and reforming, or the clouds not moving at the same speed as the surrounding atmosphere was not clear. The determination of precipitation index also showed very poor agreement between algorithm-determined values and ground truth determinations.

The problems associated with monitoring of snow cover from satellites were discussed by M. Hallikainen, P. Joma, and M. Tiuri (Helsinki University of Technology), and R. Kuittinen (Technical Research Center of Finland). They indicated that the extent of snow cover and some physical properties of the snow were discernable by the use of radar and visible wavelengths. Of the two, radar is better by far to determine the water equivalent of the snow cover, while visible data are better indicators of the extent of snow cover. Since no high-frequency satellite radar data were available to these Finnish investigators, they were forced into using Nimbus 7 radiometer data, in this case brightness temperatures determined from microwave measurements in the range of 6.6 GHz to 37.0 GHz. They found that a decrease in brightness temperature was associated with an increase in both apparent snow particle size and snow cover thickness, but only if the snow is dry. If the snow is wet, the brightness temperature is independent of the snow depth. This apparently is related to the particle size of the actual snow, which in turn is related to the freshness of the snow, so that more frequent snowfalls give rise to smaller particle sizes. In addition, crust formation, produced by surface melting and refreezing, effectively prevents determination of the snow characteristics much below the surface layer.

A simple algorithm for determining water equivalent of snow cover was used in which the water equivalent was assumed to be linearly related to the difference in brightness temperature of the snow-covered area and the same area with no snow cover. They found various problems in this procedure, including the fact that these brightness temperatures were also related to the snow particle size, the temperature of the snow, and the water content of the snow. It appears that due to climatic conditions, the algorithm needs to be changed each winter.

Other types of measurements in upper latitude regions were discussed by J. Jensen (Technical University of Denmark), including the use of advanced very high resolution radiometer (AVHRR) data at 11  $\mu$ m, in classifying regions as thin cirrus clouds, thin ice layer, or fog and low-lying clouds. The test region, between Greenland and Norway, involved two

areas, each about 520 by 160 kilometers in size. Brightness temperature statistics such as skewness and kurtosis were utilized in a k-clustering analysis technique. Even when using this advanced technique it was difficult to distinguish between ice and clouds.

Another use of the satellite data was discussed by A. Geraci and G. LaRosa (University of Catania, Italy). They used thermal imagery and multispectral scanning data from Landsat to show how an oil spill could be monitored. They believe that if remote sensing techniques had been used regularly during an oil spill incident in the Straits of Messina steps could have been taken in time to prevent much of the resulting damage.

Another study involving passive sensors was that of J. Bekkering (Joint Research Center of the European Communities, Italy). Bekkering worked in conjunction with J. Nihol from the University of Liège in using satellite data in conjunction with Nihol's numerical circulation model of the Adriatic Sea. The satellite data used were the visible bands from the coastal zone color scanner (CZCS), the Thematic Mapper (TM), and IR from the AVHRR. The measurements were used to determine the distribution of chlorophyll *a* and total suspended material. It is hoped that a circulation pattern can be inferred as these two parameters are tracked through the Adriatic. The speaker stressed the problems with this system because both chlorophyll *a* and suspended sediments used as tracers for current measurements are nonconservative parameters.

The final discussion of the use of passive satellite data was presented by S. Tassan (Joint Research Center, Italy). He compared the TM and CZCS systems because very little new CZCS data are expected in the future. (CZCS has been turned off as of 1 July, and it is doubtful if it will ever be turned on again.) TM on the other hand is expected to continue to supply data for some time into the future. His general conclusions were that TM data were about as good as CZCS data for most purposes. The atmospheric correction is very similar between the two units, and for high chlorophyll levels TM is more sensitive. However, for low chlorophyll levels the opposite is true. Sensitivity of the two systems appears to be about the same for suspended sediment, and the atmospheric correction is probably easier for the TM. From these judgements Tassan concludes that the quality of the TM data should not be significantly less than those obtained from CZCS for chlorophyll *a* and suspended sediment determinations.

Use of active satellite data is becoming more and more interesting to oceanic scientists as the date for the launch of the ERS-1 satellite approaches. Since there is no active sensor in space at this time, all preparations for the ERS-1 satellite must be done using Seasat data. T. Guymer and M. Srokosz (Institute of Oceanographic Sciences, Wormley, UK) discussed some errors that they have found resulting in a bias in sea-state determinations. This bias produces an error between 5 and 7 percent in calculated significant wave height as compared to ground truth measurements. Apparently this is due to the nonlinearity of the wave system and is a maximum during the early stages of a storm when the sea is actively developing. Guymer and Srokosz also believe there is a distinct possibility that some of the mesoscale variability seen from Seasat might be the result of this sea-state bias, especially during the period when storms are developing or decaying.

#### Future Plans

Following these experiences in the use of existing satellite data were some presentations devoted to future systems, such as ERS-1 and the Polar Platform (see page 440), or, in the case of SPOT, a system that has just come on line.

The SPOT satellite was discussed by G. Brachet (President, SPOT Image, France). He indicated that as of 6 May 1986, the SPOT satellite, which had been launched in February, had passed all tests successfully and was therefore declared operational. The initial investment for the development and launch of SPOT was advanced by a consortium of French, Swedish, and Belgian interests who hope to get a return on their investment as the corporation makes money from selling the images acquired by the satellite. Brachet indicated that the major customers will probably come from the areas of nonrenewable resources such as oil and metal exploration, mapping, and charting, and in the areas of renewable resources such as monitoring for forestry and yearly crops.

At this time, two policies have been set by the governing board of SPOT Image:

1. A strong attempt will be made to keep the prices about the same from year to year, so that people on strict budgets will not be surprised, as they were when the market shift was made in Landsat and CZCS data prices.

2. There will be one price list for all customers; that is, there will be no price differential for scientific or educational institutions as compared to commercial customers. This evoked a cry

of anguish from the assembled group, who were mostly scientists and educators, but Brachet was firm in upholding his company's policy.

An additional discouraging note was presented by J. Vandenkerkhove (VDK Systems, Belgium). He discussed the projected launch of the Space Platform in 1996 and the associated Columbus program, which has attracted a lot of attention from possible European users. His pessimistic note was based on an analysis of the cost and efficiency of the system as presently envisioned. He believes that final costs will be markedly greater than presently projected, and that the pay load will probably end up much smaller than presently projected. He addressed three specific items: size of the unit, serviceability, transportation system.

1. The size of the unit. Present plans indicate a payload of between 2.5 and 5 tons, and this large payload, coupled with the large support system required, will probably be beyond any launch capability projected for the 1990's. He questioned the capability of servicing such a platform, when in order to be serviced it must be dropped down to a markedly lower altitude. The problem of drift from the line of nodes during servicing is much greater, in his opinion, than presently thought.

2. Serviceability. Vandenkerkhove indicated that there is no real experience in this area to fall back on. The decision to attempt a system design having an extended life of at least 15 or perhaps up to 30 years is prohibitively expensive as compared to one with a shorter extended life that would weigh much less but require a higher service rate. Since it is probably not possible to design components such as tape recorders and batteries with a trouble-free 15- to 30-year life, it seems counterproductive to design the rest of the system to last for such a long period of time. His analysis showed that limited serviceability (servicing at more frequent intervals) is as cost effective as extended serviceability when optimum component lifespans are considered. Limited serviceability lowers the initial investment, making it easier to modify the later platforms.

3. Transportation system. Unfortunately, NASA has tailored the Space Platform to the shuttle bus. Flights would be limited, the performance is unpredictable, and the cost for the European effort is extremely high. It appears that Ariane 5 would be better than the shuttle bus by about 30 percent. Vandenkerkhove suggests that the European space community should investigate the use of smaller

rockets such as Titan or Hermes. These have not been seriously considered since the smaller rockets preclude an extended servicing system. He feels that by limiting the platform payload to 1500 kilograms the system would be much simpler, much smaller, much less expensive, and have a higher probability of producing the results desired.

The report from the ESA, delivered by G. Duchossois (Director of ESA), substantiated the interest of the European space community in the Columbus Project. The Polar Platform is due to orbit about 1995 and ESA is committed to be a part of that project. Duchossois also discussed the ERS-1 satellite, due to be launched in December 1989. This will be an active-sensor satellite designed primarily for gathering oceanic data. It is approved and has been funded by 13 countries, 10 within the European Space Agency plus Austria, Norway, and Canada, making it the first truly international remote sensing satellite. The payload will consist of the active microwave instrument (AMI), a radiometer specifically for sea surface temperature, and other radiometers to allow the determination of appropriate atmospheric corrections. In addition, the satellite will have a precise, built-in positioning capability.

The active microwave instrument will include C-band synthetic aperture radar, a C-band radar scatterometer for wind measurements, and an A-band radar altimeter. The satellite will contain a passive laser corner retroreflector for accurate positioning with respect to ground points and a microwave sounder for the determination of atmospheric water vapor content. ERS-1 is expected to weigh a total of about 2.4 metric tons, with a payload of about 1 metric ton. Basically its mission is to support science in general on a global and regional scale in addition to monitoring ice. Data will be utilized in both oceanic and atmospheric models, it is hoped, along with other studies in physical oceanography, ocean circulation, mesoscale features, wind-wave interaction, and sea surface topography. In addition, it will support glaciology studies by ice-sheet mapping and dynamics, and will continue to monitor the marine geoid.

The ERS-1 sensors have been designed primarily for oceanic purposes, but use of the data acquired over land will also be encouraged. The orbit will be sun-synchronous at an altitude of about 730 kilometers, giving it a period of about 100 minutes. Hopefully some data products will be available within 3 hours of accumulation. These products will include a description of wind fields, significant

wave height, wave spectra, and satellite altitude. The data will be separately processed by at least four countries, each of which will probably do processing in a somewhat different manner, allowing for differing final products.

Appropriately enough, the last scheduled presentation to be given at the meeting was one that raised some very interesting questions about policy involved with use and availability of satellite data. G. Schultz (Ruhr University, West Germany) presented a very good case for a commercial customer being allowed to get data at a somewhat lower price per scene if the total number of scenes required were very large. Brachet, from SPOT Image, responded by indicating he would take this request back to his governing board. Schultz also raised the question as to what criteria should be used in making the decision to use satellite data. It was apparent to some that for the particular project discussed, the design of a large dam, stream flow, or precipitation, current sources of data probably would have been adequate. In the rush to use high-technology products, sometimes the user forgets that low-technology data will produce the same effect. This was discussed at some length, and a participant came away with a renewed appreciation for older and less expensive alternatives to the use of satellite data.

#### Summary

EARSEL's tenth anniversary meeting was an ideal opportunity for the European remote sensing community to take stock of itself. Past accomplishments were reviewed, and future plans were revealed. As a result, a few salient facts emerged:

1. The European remote sensing community is very small. Although many of the people are high-quality investigators, progress will continue to be slow unless more young researchers are attracted into the community.

2. The effort in Europe to commercialize remote sensing has occurred before a significant basic research program has been able to produce many of the tools required to effectively use remote sensing data. Consequently, the number of economically feasible commercial uses of remote sensing data that have been successfully demonstrated is minimal.

3. It is hard to judge how much cooperation really exists between the various member laboratories of EARSEL. I noticed no evidence of any joint laboratory projects, for example.

4. There is no clear indication where funds will be found to support a viable remote sensing program in Europe. The remote sensing community itself is

both unwilling and unable to either supply or find required funds.

8/15/86

SATELLITE OBSERVATIONS OF OCEAN COLOR FOR DYNAMICS AND BIOLOGICAL STUDIES: PRESENTATIONS AT THE 26th MEETING OF COSPAR

by Jerome Williams.

The Committee for Space Research (COSPAR) held its 26th meeting at Toulouse, France, from 30 June to 11 July. COSPAR was established by the International Council of Scientific Unions in 1958 to continue the cooperative programs of rocket and satellite research undertaken during the International Geophysical Year (1957-1958). The primary purpose was to provide the world scientific community with the means whereby it could exploit the possibilities of all kinds of satellite and space probes for scientific purposes, and exchange the resulting data on a cooperative basis. Consequently, the COSPAR meeting was a very broad one addressing all aspects of space research. There were a total of 12 symposia, 16 workshops, and 22 topical meetings each lasting between 1 and 6 days, held concurrently in Toulouse. The subject material of these meetings varied from pure astrophysics to the use of satellites for earth observation.

The particular interest of this reviewer was in a topical meeting devoted to satellite observations of ocean color for dynamic and biological studies, which this report will discuss. At this meeting the objective was to survey the contributions that the Coastal Zone Color Scanner (CZCS) sensor on the NIMBUS 7 satellite has made to oceanography. The following topics were of particular interest:

- Physical oceanography--the use of color differences as tracers of near-surface flow and mixing
- Biological oceanography--mapping and interpretations of productivity patterns
- Global studies of primary production, solar heating, and carbon dioxide cycle
- Ocean and atmospheric optics, including the measurement of optical properties.

There was some thought in the initial planning to also provide for discus-

sion of the limitations that have appeared in present sensor designs and in data processing methods used; research programs now aimed at applying these data; and the plans for new sensors, processing, and observing techniques which might lead to improved capabilities in the future.

CZCS Background

There have been a number of uses to which CZCS data have been put, some of which were discussed at this conference. There were a few papers that indicated new uses for the color scanning data. By far the greatest use of the color scanning data has been in the area of biochemistry, and certainly the major use within this area has been in attempting to measure the standing crop of chlorophyll. These instantaneous measurements have often been averaged or extrapolated to obtain monthly or seasonal values, often necessary because of cloud cover during specific passes of the satellite.

As a lead into the various technical papers describing results obtained from the CZCS sensor, R. Evans (University of Miami) and C. Davis (NASA Headquarters) separately described some characteristics of the CZCS sensor. They indicated that when the sensor was launched in November 1978 the expected lifetime was nowhere near the 7.5 years that has actually been the case. However, the end is in sight. The sensor was turned off on 1 July but may be restarted in the fall, if possible, when solar energy reaching the power panels of the satellite increases. Meantime, all data being utilized by investigators is historical data.

Chlorophyll Determinations

The determination of chlorophyll a from CZCS data has characteristically been done by various algorithms, which fall into two classes. The first class, used primarily by American investigators, includes the assumption that the energy emitted from the sea surface at a wavelength of 750 nm is negligible. This assumption is evidently valid for clear ocean waters (Case 1) while it is not valid for turbid waters found in many coastal regions around the European continent (Case 2). That difference is involved with the algorithms used for the atmospheric correction and the increased scattering of turbid waters. Europeans have used different atmospheric correction algorithms (the second class) because they are primarily interested in Case 2 waters, as opposed to Case 1 waters of interest to American investigators.

This was the major problem area discussed by various investigators, but P.

Deschamps (Centre Spatial de Toulouse, France) described some other problem areas including the calibration of the unit, the actual chlorophyll algorithm, and the variation of the solar constant. He suggested that the resulting error may be as large as an order of magnitude in the determination of chlorophyll *a*.

S. Keevallik (Institute of Astrophysics and Atmospheric Physics, Estonia, USSR) emphasized the atmospheric error which leads to a very large error in chlorophyll *a* determination if various assumptions are not modified. These include atmospheric homogeneity, single scattering, and the constancy of atmospheric parameters.

#### Suspended Sediments and Gelbstoff

A. Morell (Laboratoire de Physique et Chimie Marines, France) addressed this problem also. He apparently has been successful in developing an algorithm to account for the atmospheric effects when Case 2 waters are being considered.

Morell was the first to attempt to separate the signal components resulting from suspended sediments, chlorophyll *a*, and gelbstoff (yellow substance); this is important, especially when the chlorophyll content is low. He believes that the possibility of separation of these three substances does exist, but he has not yet been successful in doing it.

J. Fischer (Forschungszentrum Geesthacht, West Germany), suggested another methodology of separating these three parameters. The methodology was one of inverse modeling, which requires a tremendous amount of computer effort. Currently, about one minute of computer time is required for analysis of each pixel. Although this is an unrealistic amount of computer time for data analysis, the methodology can perhaps be improved.

#### Chlorophyll by Fluorescence

Another methodology for determining the total amount of chlorophyll, which is just starting to receive some attention, is by using the effect of fluorescence by chlorophyll.

J. Gower (Institute of Ocean Sciences, British Columbia, Canada) described some measurements of fluorescence which have been made. These are passive fluorometric measurements which use the sun's energy to produce the fluorescence. Various problems have cropped up, including the fact that the amount of sunlight present seems to affect the relationship between fluorescence and the amount of chlorophyll present.

B. Topliss (Bedford Institute of Oceanography, Canada) discussed some fluorescence measurements she has made. Her results were somewhat more positive than

Gower's, but indicate that passive and active systems both give essentially the same result. These data are preliminary in nature; she has not sampled any areas of low chlorophyll, for example.

Y. Ding (First Institute of Oceanography, China) also reported on fluorescence measurements and indicated that the fluorescence response is very much dependent on the amount of suspended sediments. He gets around this by the fact that chlorophyll *a*, *b*, and *c* all fluoresce at different wave lengths, so it is possible to get reproducible values for different species if the fluorescent ratios of chlorophyll *a* to chlorophyll *b* to chlorophyll *c* are determined. The advantage of this system appears to be that deeper penetration into the water column is possible.

R. Doerffer (Forschungszentrum Geesthacht) found that the character of fluorescence did not appear to change with the level of solar irradiance, and he believes that fluorescence is a good measure of chlorophyll. His results seemed to be quite stable as long as the solar elevation was between 30 and 60 degrees.

In general, the investigators seemed to agree that the determination of chlorophyll *a* was probably a reasonably well-defined procedure for waters considered to be Case 1; i.e., the central portions of the major oceans. However, for Case 2 waters, where both suspended sediment and gelbstoff loads are high (in addition to doubts about atmospheric parameters) the possibility of large errors and large variability in chlorophyll *a* calculations is quite high. Nevertheless, many investigators have not only used absolute chlorophyll *a* measurements in various studies, they have used them as an indicator for other processes.

C. Trees (Scripps Visibility Laboratory, California) described a methodology for determining the total change of chlorophyll with respect to time. Using the simple relationship that total change is equal to the sum of local change plus adjective change, Trees' group was able to use a sequence of images to determine the chlorophyll gradients and the horizontal velocity of the surface water by tracking specific features of the chlorophyll bloom. Local change in chlorophyll was measured at specific points on the image by simply noting the change in calculated chlorophyll at the same point between two images separated by a known time interval.

#### Primary Productivity

A number of investigators described methodologies for determining values for primary productivity. Among these was J.

Andre (Laboratoire de Physique et Chimie Marines, Université Pierre et Marie Curie, France). He used historical data acquired off the coast of Africa and assumed that the primary production was a function of the sea surface temperature anomaly, day length, and the chlorophyll *a* values taken at different times.

T. Platt (Bedford Institute of Oceanography) described a scheme for determining the time rate of change of the bio-mass. He was able to do this from measurements of surface chlorophyll by establishing the ratio between new productivity and total productivity. The scheme for determining this ratio involved the variation of nitrate (determined from *in situ* measurements) along with the total bio-mass determined from CZCS measurements.

T. Volk (New York University), describing a somewhat different method for the determining the rate of change of bio-mass, also used this ratio of the new production to the total production. He suggested that the simple relationship described by Platt for the new to total production ratio and nitrate was actually more complex, being in reality a family of curves resulting from different ecological systems.

J. Minster (Centre National d'Études Scientifique/Group de Recherches en Aérodesia Spacials, Toulouse, France) described attempts to look at the primary production by looking at the global carbon cycle as part of the Global Ocean Flux experiment (GOF). He believes that the knowledge of the nutrient transport is necessary for predicting new production and therefore that any system involving calculation of global ocean fluxes of carbon must of necessity involve *in situ* measurements along with satellite measurements.

B. Moore (University of New Hampshire) tends to agree with Minster in that he has developed a model for the global carbon cycle which includes a number of parameters that must be determined from *in situ*. Even though the box model he described is quite crude, it is still extremely complex since it deals with biotic processes, and each interface between the various boxes results in a new biotic process equation. The net result is a 96-box model with over 900 equations and over 600 unknowns.

Another interesting application of CZCS data was described by S. Groom (Imperial College, London); a particular kind of plankton coccolithophore, being almost spherical in shape, is an excellent light scatterer. For this reason, a bloom of this particular organism results in a very strong signal at the CZCS sensor. He showed some scenes of typical

blooms of this type and indicated that these blooms might be used as an indicator of various biotic processes, since they appear and disappear in a relatively short period of time.

#### Chlorophyll as a Tracer

CZCS data have been used for the description of physical processes also. S. Boxall (Southampton University) described a study in which features of a chlorophyll bloom were used in a study of tidal mixing in the English Channel. A particular feature of the bloom occurring in the spring was chosen as being one easy to trace in consecutive scenes. Showing data from 1985-1986, Boxall indicated that with the late spring present in Europe during this year, the feature was a month to 6 weeks late on showing up on the satellite pictures. Since it did eventually show up, the validity of the hypothesis that it was a seasonal feature was vindicated. Tracking this feature from scene to scene, the group at Southampton was able to determine some of the coarser features of the tidal circulation in the English Channel.

K. Denman (Institute of Ocean Sciences, Canada) and M. Abbott (Scripps Institute of Oceanography, California) used chlorophyll to look at changes, hoping to get at the turbulence spectrum. The spectrum that they retrieved from these data showed a slope of -2 rather than the -5/3 slope usually found.

As might be expected, some work was reported having to do with fronts associated with a demarkation of a chlorophyll patch. J. Eert (Institute of Ocean Sciences, Canada) described methodology by which he fits CZCS scenes in various mathematical models resulting in front configurations that show squirts and eddies along a chlorophyll front, much as seen along the coast of California. This group is actively working in this area trying to fit dynamic models to these chlorophyll fronts as seen on CZCS images.

M. Lewis (Dalhousie University, Nova Scotia) is using frontal characteristics to try to estimate local heat fluxes. He claims that the variability in surface pigment concentration seems to be responsible for the variability in local heating.

#### Optical Properties

A markedly different kind of study which has been going on for some time now, is that of R. Austin and W. Hering (Scripps Visibility Laboratory). They are attempting by means of CZCS data to map the worldwide distribution of the diffuse attenuation coefficient for surface waters. Their report of the extent



of progress of this mapping effort indicates that so far most of the northern hemisphere data have been analyzed.

#### Future Plans

It is obvious that the color sensor is extremely popular among a growing group of oceanographers. It has a great deal of versatility and is especially attractive to the biological oceanographic community. With the news that CZCS is now turned off and the high probability that it is permanently out of operation, there was a great deal of interest in any information as to when a new ocean color sensor might be flown.

C. Davis (NASA Headquarters) indicated that there is an ocean color imager in the works, to be flown perhaps in 1989 or 1990. This imager will have improved signal-to-noise ratio and greater sensitivity, along with a built-in solar diffuser plate for improved direct calibration. There will be a total of 8 channels centered at 443, 490, 520, 566, 620, 665, 765, and 867 nm. The first six channels will have a bandwidth of 20 nm, while the last two will be somewhat wider.

The American satellite corporation (EOSAT) is seriously considering flying this instrument, but no definite decision has been made. There is also an extremely strong possibility that the Moderate Resolution Imaging Spectroradiometer (MODIS), which can be used for ocean measurements, will be flown on the polar platform scheduled for launch in the mid-1990's.

Another future satellite system that will carry color sensors is the SPOT 4 and 5 series, planned for launch around the end of 1992. SPOT sensors will have five channels centered on .45, .55, .65, .83, and 1.66  $\mu\text{m}$  and will be of the push-broom scanner type rather than the mechanical scanner that has produced so many problems in the CZCS satellite. The major limitation for many oceanographers is that the satellite will be used primarily for the northern hemisphere, so that the southern oceans will be greatly neglected.

#### Summary

The ocean color meeting, attended by approximately 80 people, consisted of four sessions over a period of 2 days. Most of the attendees were European, but the few Americans who did attend were obviously key people, and I got the distinct impression that these people were far ahead of their European counterparts in the analysis and application of data from the CZCS. This may be due to a number of factors, three of which are given

here: In the first place, there was a time lag of as much as 5 years between the time CZCS went into orbit and the time the data were readily available in Europe. This allowed American investigators to get a big jump on European users of these data. Second, since this was an entirely new field, there was (and still is) a lack of imaging processing facilities in Europe. (This situation is changing as hardware becomes less expensive, but historically this has been a major reason for the Europeans lagging behind the Americans.) Third, it has been suggested that in the early years, there was a lack of interested people. The European scientific community is small to begin with and when the new study area of ocean color data analysis came on the horizon, only a very small segment of this population was willing to learn the new technology and begin to use it. In recent years, it is obvious that the Europeans are starting to become more interested in ocean color as a tool for oceanography, because the power of this tool is becoming more and more obvious. I had the distinct impression that the universities are now turning out people who have a knowledge of this tool and will be willing to use it; also, that older, more established investigators are starting to use it. The American lead may disappear in the near future.

The attendees at the conference were all very much aware of the limitations of the use of color data in what they were doing. They seemed to agree that the most profitable uses were for long-term studies where surface effects were of primary interest. This, of course, is ideal for studies involving chlorophyll measurements and for surface optical property measurements.

Unfortunately, there was no critical evaluation at this meeting of what can and what can't be done with color data, nor was there much discussion about the fact that chlorophyll is a nonconservative property, distributed vertically in an unknown manner. Patchiness was a subject not discussed at all. There still seems to be a dichotomy between methods used by American data analysts, who tend to disregard atmospheric and high-turbidity problems, and the European investigators, who are very much concerned with these problems.

I believe that this conference would have benefitted from a critical evaluation of the work that has been done to this date with the color sensors available, so that future plans could be effectively formulated. Since there will be a hiatus of new data for at least a few years, this seems to be the time to decide what to do with the data and how to



use it most productively when it becomes available again.

8/18/86

## Physics

### LASER SPECTROSCOPY SERVES BASIC RESEARCH AT THE UNIVERSITY OF GRAZ

*by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.*

The Physikalisches Institut (Institute for Physics) at the University of Graz, Austria, has a grand history: Boltzman, Mach, Hess, Wegener, Schrödinger all contributed to make it, in the past, one of the leading research centers in central Europe. Since those days, the Institute has been split up into smaller units (departments for experimental, for theoretical, for applied, and for geophysics), and the usual fiscal barriers inherent in current-generation Austria did not help to get back the glory of the past. However, things are stirring. Recently a new chair was established within the Department of Experimental Physics, and Professor W. Kiefer, formerly senior professor at the Institute for Physics, University of Bayreuth, West Germany, has been invited to be its first occupant. In addition, effective October 1986, Kiefer will become the new Director of the Institute, while retaining his role as head of the First Research Group for Laser Spectroscopy.

During my visit to Graz in April, Kiefer enthusiastically showed me around part of the fine, classical building (dating from 1876) which is now being remodeled and richly equipped with front-line, contemporary equipment.

In this article I will sketch Kiefer's planned research, then review the current efforts of the Second Research Group for Laser Spectroscopy, which is under the leadership of Professor F.R. Aussenegg (currently still serving also as Director of the Institute). It may sound odd to American readers that a medium-sized department has two research groups in the same area, each under the

leadership of internationally acknowledged scientists, but in the central-European sphere this is a well-established tradition. Moreover, the two research groups complement each other very well. Kiefer's focuses on phenomena related to the frequency-scale, Aussenegg's to those on the time-scale.

### Applied Raman Spectroscopy

Kiefer's speciality is nonlinear coherent Raman spectroscopy. In particular, he was one of the early developers of the coherent anti-Stokes Raman spectroscopy (CARS). However, his plans for the new research group are more application-oriented. One of the projects he has in mind (in fact, a research line he already initiated in Bayreuth) is the detailed physico-chemical study by CARS of the combustion process in internal combustion engines and rockets.

Another laser project involves spectroscopic study of laser-levitated small particles (0.5- to 50- $\mu$ m diameter extension). As is known, new, exciting resonance phenomena can be expected when the characteristic size (say, the circumference) of the levitated particle is a small integral multiple of the probing laser light wavelength. Study of the diffraction, together with spectral analysis, will give much insight regarding the properties of the small particles. This will further our knowledge on metal powders, aerosols, and other small-particle systems.

A third project will investigate the behavior of molecular crystals under high pressure and at low temperature. Study of laser scattering (and, in particular, nonlinear Raman spectroscopic methods) will shed light on the anharmonicity in the crystal-binding forces.

Finally, Raman spectroscopy of two-dimensional systems (like polyacetylene films) will be conducted, with an eye to learn about basic physical properties of such condensed-matter states (which are expected to play an important role in future microelectronic devices).

Kiefer expects that his group (now about five people) will grow to a 12- to 15-member strong international research group within the next 2 or 3 years. In my opinion, this group deserves watching and assistance.

### High Time-resolution Laser Fluorescence Studies

The second laser spectroscopy group, under Aussenegg's leadership, is historically the earlier and has already earned respect and reputation in the European community. The object of its ongoing research is to apply picosecond resolution

studies to the investigation of molecular characteristics and dynamics.

Investigations in this area demand, typically, picosecond resolutions. Therefore, the researchers built a passively mode-locked Nd:Glass laser system, consisting of an oscillator (emitting trains of pulses with 6-ps duration), a electro-optical single-pulse selector, two amplifier stages (leading to 100-mJ output), a frequency doubler (or tripler) crystal, and, if needed, a Raman frequency shifter cell. The response of a sample to the pulses is studied in two ways: first, time-resolved fluorescence (using a commercial 2-ps resolution streak camera); and second, time-resolved absorption studies. In both cases, an optical multichannel analyzer was used. Readers of *ESN* may recall that, in a previous article (*ESN* 40-1:25-30 [1986]) I reported on very similar molecular dynamics studies done in the laboratories of Professor Kaiser, Technical University, Munich, West Germany. But (despite occasional cooperation) there is no repetition of effort here. Aussenegg explained that, while they use similar techniques, the major difference lies in the orientation toward applications. While Kaiser's group focuses on studying nature-made molecules (including biologically important substances), Aussenegg's researchers concentrate on manmade molecules, to be engineered for special purposes. (Parenthetically: the Graz scientists also did some bio-physicochemical studies, on the light-sensing plant pigment phytochrome, which, despite its surprising behavior and role in plant growth, has not been studied elsewhere.) More specifically: Aussenegg's group is very keen on understanding the basic physics that govern the behavior of manmade (molecular-engineered) substances, especially in low-dimensional form. One may say that these scientist are conducting fundamental research in an area that, perhaps, could lead eventually to the realization of the dream called molecular electronics. I was very impressed that these physicists at Graz rejected the headlong drive into a potentially most exciting development (electronics with extremely short response-and-transmittal times as well as maximal information storage) but, instead, want to first thoroughly investigate the underlying basic physical structures and processes.

As a starting point, the Aussenegg group built, for example, a system which incorporated a special dye (DiIC18) in a Cd-arachidate Langmuir-Blodgett monolayer assembly. One structure they prepared is illustrated in Figure 1. Here A stands for the Cd-arachidate host; the chromophore B (DiIC18(3)) denotes the active guest-

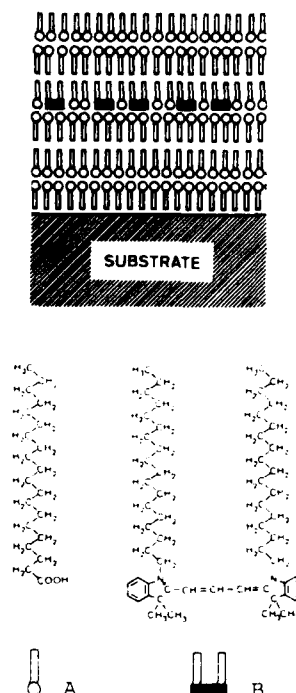


Figure 1. Monolayer assembly.

molecule. Once good quality samples of this and similar systems were fabricated, the scientists investigated picosecond time-resolved fluorescence decay in these assemblies. The goal of this research was to study radiationless energy transfer (ET) between dye molecules by dipole-dipole interaction. As is well known, this interaction depends inversely on the 6th power of intermolecular distances and is very sensitive to the relative orientation of the interacting molecules. Clearly, the system they studied is a simplified version of a molecular architecture which could serve as a carrier of an artificial molecular information processing system.

The researchers' spectroscopic results permitted a definite dynamical interpretation: a so-called Förster-type ET mechanism (i.e., energy transfer to nonradiative dimers) was verified.

I conclude with another current line of research which aims at the investigation of fluorescence emission by molecules near a metal surface. The physical properties of molecules can be strongly influenced by proximity to a solid surface. The study of these phenomena has obvious practical relevance for surface physics and technology, but it also involves important questions of basic

physics. The influence of the surface of the nearby (adsorbed) molecules is due to a variety of processes, but in the case of a metal surface, interactions with surface plasmons is important. Aussenegg's recent work aims precisely at clarifying the mechanism of electrodynamic coupling between the transition dipole of an adsorbed dye molecule and surface plasma oscillations in the metal.

To excite surface plasmons, submicroscopic roughness of the surface must be achieved. Aussenegg's group arranged for this by producing silver island films on glass or fused silica slide substrates. This was achieved by slow thermal evaporation in high vacuum. Then, dye molecules were attached to the silver island film by the Langmuir-Blodgett technique. The planned buildup of successive monomolecular fatty acid layers allowed for control of the incorporated active dye molecules' orientation, and of their distance from the metal islands. The samples so prepared were then subjected to picosecond laser pulses, and the scientists studied the shape and intensity distribution of the fluorescence spectra. Even though similar research with CW measurements have been done in the past, Aussenegg was the first who successfully used time-resolved fluorescence measurements on dye-coated island films. He pointed out to me that if the exciting laser pulse is short compared to the fluorescence lifetime of the molecules the shape of the resulting fluorescence decay curve represents completely new information which is not available by CW measurements. In particular, the Graz researchers succeeded in separating the different influences of enhancement and dissipative loss that ensued by the involved cooperating effects. Thus, deeper insight into this complicated area of surface physics has already been achieved, and further experiments are planned to complete the study of the interaction mechanisms.

#### Concluding Remarks

I did not have the opportunity or specific interest to visit other research groups at the Department of Experimental Physics in Graz, but what I saw in the two groups working on applied laser spectroscopy gave me a sense of respect for colleagues who learned to work successfully under hard circumstances and who are on their way to building up a leading research center in the German-speaking area of Europe.

#### THE 6TH EUROPEAN SYMPOSIUM ON OPTOELECTRONICS: A MIXED BAG

by Paul Roman.

Osiris, the Optoelectronics Scientific Industry and Research International Society, in conjunction with the French Society for Laser Medicine, sponsored a large-scale meeting and exhibition in Paris at the Palais des Congr s, from 13 through 15 May. The official name of the get-together was "The 6th European Symposium on Optoelectronics," but the world knew it as "Opto 86."

There were 126 talks presented (a few invited papers lasted 25 minutes, the rest 20 minutes). There were 115 exhibitors, showing almost everything in optoelectronics and related areas. (A list of exhibitors and, following that, the appropriate catalog-entry of each exhibitor's demonstration, is available upon request.) The overwhelming majority of the conference participants was French, and almost the same applies to the speakers, although they were more varied, including also non-European (American and Japanese) colleagues. Because of the fact that the meetings ran in three parallel sessions, with many participants simultaneously viewing the exhibition, and because the bookkeeping of the organizers was vague, it is hard to tell the exact number of participants. I would estimate it to be about 230.

The talks were organized as follows:

1. Fiber optics I--optical fibers in multiservice broadband networks (optical fiber networks in French and other European countries; past, present, and future; network architecture; transmission systems; distribution network components; future prospects)
2. Fiber optics II--applications other than in communication networks (optical fibers in instrumentation and metrology; biomedical applications; fibers in adverse environments; fibers in security systems)
3. Optics and optoelectronics (new optical materials, optoelectronic components)
4. Lasers (laser development, laser materials, lasers as research tools)
5. Displays (LED, plasma, liquid crystal, laser, electroluminescent, fluorescent, and holographic displays; display arrangements for special applications).

The tenor of the overwhelming majority of talks was highly technological. I will review only presentations that are sufficiently broad and more basic in

their scope. But my selection is not quite rational: it was not always dictated by a value-assessment or by my judgement regarding the topic's importance for current Navy research efforts. Rather, practical limitations of what I could attend, whether it was presented intelligibly as far as I am concerned, whether an acceptable abstract was made available, (and, occasionally, whether the "simultaneous translation" technology worked or not) were factors affecting my choice. I will group my article by subject area, not necessarily corresponding to the formal organization of the sessions. Incidentally, I have abstracts (most in French, some in English) of many talks. On request, I will be glad to send copies for individual use by colleagues.

#### New Optical Materials and Optoelectronic Devices

The keynote address, a review of recent advances in ultralow attenuation infrared fiber materials was given by D. Tran, "our own man" in the Naval Research Laboratory, Washington, DC. It was well-complemented by a report on the present status of research on new laser materials, which was put forward by M. LeDuc (École Normale Supérieure, Paris) and D. Vivien (University of Paris V).

Two related works on new glasses were contributed by the famous Laboratoire de Chimie Minérale of the University of Rennes, France. The first was read by G. Fonteneau, and concentrated on new indium-based fluoride glasses for mid-infrared transmission up to 8  $\mu\text{m}$ . Particular attention was paid to the search for the most stable vitreous materials in this class of composites. Typical ternary systems of study were (BaThIn)-fluoride solid solutions. In the class of quaternary systems, (BaInZnTh)-fluorides and (BaInZnYb)-fluorides were given special attention. The second talk from Rennes was presented by the leader of the group, J. Lucas, and it gave an extensive report on their recent work relating to chalcogen halogen glasses, which can transmit efficiently up to 15  $\mu\text{m}$ .

I was quite impressed by the talk of C. Jacobini (University of Maine, LeMans, France) who talked about lead and transitional metal fluoride glasses. These substances have a wide transparency window (between 0.2 and 8  $\mu\text{m}$ ). They were found to be very stable in air, and with variable durability in water. The experiments were carried out with  $\text{PbF}_2\text{-MnF}_2\text{-GaF}_3$  and with  $\text{PbF}_2\text{-BaF}_2\text{-InF}_3$  ternary systems. The vitreous phases can be stabilized by the addition of small amounts of  $\text{AlF}_3$  and/or  $\text{YF}_3$ . Vapor deposition allows

for the preparation of regular vitreous films with 8- to 20- $\mu\text{m}$  thickness, which have optical properties similar to the bulk glasses. This result could be utilized for flat waveguide applications.

More in the line of optoelectronic devices was the presentation by B. Orsal, on behalf of a group of researchers at the Centre Électronique de Montpellier and SAT-Paris, who advocated the use of  $\text{Hg}_{0.5}\text{Cd}_{0.5}\text{Te}$  photodiodes in future optical fiber transmission systems that will work between 1.5 and 2.5  $\mu\text{m}$ . This composite has a bandwidth of only 0.48 eV. It was found that, following ionization at impact, a substantial charge carrier multiplication ensues. This suggests that avalanche photodiodes which may work well even at room temperatures could be fabricated.

An interesting presentation from the Centre National d'Études Scientifique (CNET, Bagneux) read by I. Ledoux, reported on work done in cooperation with the Laboratory of Applied Optics at Palaiseau. These researchers are exploring possible new avenues in the area of nonlinear optics based on organic materials. In particular, they call attention to N-(4-nitrophenyl)-(L)-prolinol, (NPP), and nitro-4-phenyl-N-(methyl cyano-methyl)-amine, (NPAN), which have a monocline and an orthorhombic crystal structure. These materials seem suitable for both bulk and low-dimensional applications. The nonlinear coefficient  $d_{21}$  of NPP is rather high ( $2 \times 10^{-7}$  e.s.u.) and it has a sub-picosecond nonlinear response time. Amplification with a remarkable gain ( $10^4$ ), and also parametric oscillation at 620 nm, was observed. On the other hand, NPAN was used to fabricate monocrystalline waveguides for HeNe laser light.

I conclude this section with recalling a potentially interesting episode. A Polish researcher, A. Borkowska (Institute of Automation, Szczecin), was scheduled to talk on magneto-optical beam converters in optoelectronic devices. However, she did not turn up and no explanation was sent. According to the prepublished abstract, the talk was to report on laser beam power modulation by magnetic field strength control, including magneto-optical switching, optical filters, and power-limiters. The new materials used in the experiments were Bi-substituted magnetic garnet films, grown by liquid phase epitaxy.

#### Imaging and Visual Displays

Even though sessions dealing with these subjects were well attended and the program was rich in variety, the talks were mostly market-oriented technical reports. But I found three presentations very interesting.

E. Schulze (H. Hertz Institut, Berlin, West Germany) described research leading fast to practicable large-screen three-dimensional (3D) television representation. The method is based on holographic imaging techniques. The major point is that the object is scanned by ordinary, noncoherent light. Using a wide-angle telescopic two-dimensional camera and other optical elements, a series of images is produced (from slightly differing perspectives) which are then artificially synthesized into a hologram by using a "holographic valve." The hologram is read by a local laser light source. The synthetic hologram is projected onto a holographic screen (produced by a Fresnel zone plate effect), and thus, a large (3D) image is obtained. The holographic valve (i.e., the crucial optoelectronic element of the system) is a cell that has a photoconducting layer followed (after an isolator) by an elastic material layer; a low voltage is applied across the cell. The instantaneous hologram is produced, of course, in the elastic material, as a density grating. Experiments were also conducted in which the elastic material was replaced by a liquid crystal layer, in which case refractive index modulation led to the hologram.

F. Nouredine, reporting on research at the Mobile Robotics Institute (INSA) at Rennes, France, was also concerned with 3D vision systems. He described the theoretical studies and the basic experiments that have the goal of realizing a 3D panoramic vision sensor, which is based on the principle of active triangulation. In essence, the system consists of a laser source (a monochromatic 634.8-nm HeNe laser, with 5-mW power), two orthogonally positioned rotating mirrors, and a one-dimensional CCD-array camera. Actually, the x,y,z coordinates of the illuminated target are determined by telemetry of distance variations. These are calculated, of course, by sophisticated microprocessing control and electronics, programmed by a detailed model of specular and diffuse reflection.

I conclude with a brief report on a novel imaging device system. K. Kuroda (Laboratoire d'Annecy-le-Vieux de Physique des Particules, France) described research at his institution aimed at improving the remarkable qualities of position-sensitive photomultipliers (commonly called "multi-PM") which were first introduced in 1979. The need for magnetic fields in the conventional multi-PM devices limits the size of the sensitive area. The LAPP researchers' attempt to circumvent this problem by constructing a hybrid system, which consists of an image intensifier followed by a multi-PM. In

particular, they constructed a  $\gamma$ -ray imaging system with a conventional Thomson-CSF large-size intensifier. They achieved fast imaging of 122 keV  $\gamma$ -rays with very good spatial resolution. Current experiments, done in collaboration with the Laue-Langevin Institute at Grenoble, aim at using a similar hybrid photoelectronic device for studying thermal neutron diffraction.

#### Lasers

The reputation of German and British research in developing pioneering quality semiconductor lasers is now well respected. At the symposium, there was one pioneering paper on semiconductor lasers presented by each of the two countries.

B. Stegmüller reported on current work done at the Munich central research laboratories of Siemens AG. He described progress in developing high-quality InGaAsP/InP metal-clad ridge-waveguide (MCRW) lasers, primarily intended for optical communication at 1.3  $\mu$ m. These devices (first reported a year ago in the *Japanese Journal of Applied Physics*, 25, No. 2 [1986]) are prepared by liquid phase epitaxy. Stripe widths of experimental samples have been arranged to lie between 2 and 3  $\mu$ m. The lowest CW-threshold-current so far was found with 2- $\mu$ m-wide stripes that have a cavity length of 200  $\mu$ m; it was only 20 mA (at 25°C). With heat-sinks, CW operation could be maintained up to 85°C. Near to threshold, single-mode operation was obtained; but for current-levels 1.5 times the threshold (giving 4- to 5-mW light output), the spectrum broadens. Since MCRW devices have extremely low series resistances (2 to 3  $\Omega$ ) and very low intrinsic capacitance, they have an unusually high modulation capacity. This behavior was discussed in detail by Stegmüller.

British progress in the field of low threshold (20 mA), reliable, buried heterojunction lasers suitable for demanding long-haul transmission systems was proudly reviewed by A.-A.-M. Rashid, on behalf of STC Defense Systems, Paington. He reported that their lasers, emitting at 1.3  $\mu$ m, have stable single-mode operation, high operational stability under demanding high bit-rate modulation conditions, and a very long lifetime. They can now be manufactured and packaged routinely. The major problem the researchers had to solve was the proper control of the doping levels in the "thyristor" layers, because this influences strongly the current-leakage.

Work on the development of a solid-state laser, using a novel medium, was reported from the CNET-Laboratories (Bagneux, France), and was read by J.M.

Breteau. He talked about Ni-doped  $\text{MgF}_2$  lasers. Vibrational lasing activity for such systems was observed in 1963, but interest was lacking until recently. Apparently, the first tunable  $\text{Ni}^{2+}:\text{MgF}_2$  laser was put together by this CNET group only 4 years ago. Since then, a very spectacular development occurred. The current version uses 5-mW pumping from a Nd:YAG laser, which causes an initial transition from the ground state to a vibrational level in the  $^3T_2(^3F)$  electronic state. (In earlier work, 0.8- $\mu\text{m}$  Kr laser pumping into the  $^3T_1(^3F)$  state was employed, but a number of difficult problems were encountered with this approach.) The output is continuously tunable between 1.608 and 1.73  $\mu\text{m}$ , and has 190-mW power. (With Q-switching, picosecond pulses of 140-W peak power were also obtained.) The slope efficiency is 10.5 percent. Three percent frequency stability can be achieved. Regarding some technical features: the small cavity uses two or three mirrors, and the crystal must be cryostatistically cooled. The best results were obtained with 2 percent doping; but experiment and theory suggest that much higher power could result if it were possible to raise doping to a 10 percent level, which is very difficult because uniformity in the sample and maintenance of optical quality must be guaranteed too. Incidentally, the Bagueux researchers tried to use their cavity arrangement also with other unusual crystals, including Ti-doped  $\text{Al}_2\text{O}_3$  (which lases in the neighborhood of 800 nm). For this material, tunable room temperature operation is possible. No details were given.

Short-pulse laser system development was reported by two groups. The first speaker, J.L. Boulnois (University of Paris at Orsay, France; announced the development of an entirely novel, simple, and inexpensive dye-laser generator of tunable picosecond pulses. (In passing, Boulnois mentioned that in certain aspects of this research, there was cooperation with scientists at the University of California, Riverside campus.) As is well known, the usual method for obtaining short pulses (a CW mode-locked pump laser, a synchronously pumped dye laser, and a multistage amplifier pumped by an additional YAG) is expensive, bulky, sensitive, and needs much experience to operate. The alternative, developed by Boulnois' group, is a short-cavity dye laser. The laser cell is pumped by the 15-mJ 32-ps pulses from the frequency-doubled (532 nm) output of a mode-locked YAG laser. The same YAG also pumps four amplifiers. The oscillator itself is a surprisingly short, 5- to 8- $\mu\text{m}$  long Fabry-Perot resonator, completely filled

with dye solution. The mode-spacing is large enough to have only one mode lasing for a tuning range between 30 and 35 nm (depending on the dye). Tuning is achieved by changing the mirror spacing with piezoelectric actuators. Very high spacing-stability is achieved through an active feedback control system that uses a reference-wavelength-value generator. (In fact, the feedback control system can be used also for additional tuning, viz. by electronically setting the reference wavelength.) As already mentioned, the amplifiers are pumped by the same picosecond laser pulse as is used to pump the oscillator. The pumping of the amplifiers is automatically synchronized with the arrival of the pulse to be amplified. All amplifiers are pumped in near-collinear configuration. The output of the system, as now realized, is continuously tunable between 540 and 660 nm. At the peak (at 595 nm) the power is between 1 and 2 mJ. The pulse duration is between 7 and 15 ps. The background noise is less than 3 percent. Newer experiments verified frequency doubling from 270 to 300 nm with a 10 percent efficiency. (Boulnois predicts that, with conventional nonlinear frequency conversion techniques, eventually the system will cover the range from 220 nm to 5  $\mu\text{m}$ , maintaining the picosecond pulses with good quality.) Recent experiments also indicate that further pulse shortening is possible: if pumping is done with 16-ps pulses, the output consists of 3-ps pulses, and no relaxation oscillations occur.

The second talk on short-pulse techniques was given by F. Jolly, who reported on joint research between Photon Science Instruments at Palaiseau (France) and Lambda Physik at Göttingen (West Germany). She described a new picosecond excimer laser system. This system is based upon an oscillator-amplifier excimer laser in combination with a short-pulse dye laser. The oscillator (with a stable oscillator arrangement) delivers a signal which is injected into the amplifier which has an unstable resonator optics. A quencher laser cavity (with a dye) is also used. The oscillator and amplifier excimer lasers are XeCl (308 nm) and KrF (248.5 nm) tubes. The dye laser (and quencher) uses cumarin. (I think the system is quite similar to the experimental arrangement set up a year or so ago at the Physics Department, Optics Group, Imperial College, London; see ESN 39-5:211 [1985]). Jolly reported that ultraviolet pulses up to 20-mJ energy and less than 30-ps duration were obtained. The repetition rate was 25 Hz. The integrated background noise was less than 10 percent. She considers the system as a

reasonable compromise between simplicity and desired pulse shortening, and as eminently suitable for generation of stable UV pulses with gigawatt peak power at different adjustable excimer laser wavelengths.

I conclude this section on laser research by reviewing briefly a contribution from the Kaliski Institute of Plasma Physics and Laser Microfusion, Warsaw, Poland, which was read by A. Dubik. This research described high-power laser beam propagation optimization. A powerful numerical computer simulation has been devised, based on the exact propagation equations and allowing for nonlinearity of the medium and linear and nonlinear losses, as well as thermal effects. Apertures, pinholes, relay systems (telescopes), and amplifiers in various combinations and arrangements were included as parts of the propagation channel (about 22 m long). The optimization was aimed at a high fill-factor, a cut-off height of the order of  $10^{-3}$ , small power losses on the apertures, and high degree of homogeneity of the amplified radiation. Some experimental verification of the model was done on the institute's home-built Nd:Glass laser.

#### Concluding Remarks

As my review indicates there were a number of excellent presentations but, overall, OPTO 86 could be characterized more by breadth of coverage than depth. Perhaps the way to look at these OPTO meetings would be to consider them as adjuncts of rather limited scientific value to the excellent exhibitions which they stage.

8/15/86

## **News and Notes**

### ONR BRANCH OFFICE, LONDON HAS SPONSORED A SESSION ON THE FUNDAMENTAL PHYSICS OF MICROSTRUCTURES

#### Introduction

Following the stimulus of a joint research program under the ESPRIT initiative, a winter school, entitled "The Physics and Fabrication of Microstructures," was held at Les Houches, France, from 25 March through 4 April. Sixty students (mostly young researchers) attended 62 lectures delivered by 35 specialists. Ninety percent of the students and 70 percent of the speakers came from European nations. The spectrum of the

school was very broad--herein rests the success of the meeting.

The Office of Naval Research Branch Office, London, sponsored a particular research session, named "Fundamental Physics of Microstructures." Four major talks formed the core of this session. A brief description of these talks is given below.

#### Contributions

Probably the widest scope of analysis was given in the contribution by J.R. Baker (Department of Electronics and Electrical Engineering, University of Glasgow, UK).

He surveyed the quantum transport theory for small geometric structures. A section on quantum ballistic transport was mostly tutorial and introduced basic concepts, including also less known topics such as high-field effects in scattering and screening, and disorder effects. The second part of the lectures was on ballistic tunnelling phenomena. Escape from quantum wells was a particularly fascinating topic. The third (and last) part of the presentations took up the topic of hot electron tunnelling, a field with unusually vigorous current research activities. In his concluding remarks, Baker indicated that tunnelling and interference phenomena are likely to be of much greater importance than the distortion of scattering processes in the large inhomogeneous fields. A quantal description of scattering in strong inhomogeneous fields is still outstanding, Baker pointed out.

R. Rammal (Centre de Recherches sur les Très Basses Températures, CNRS, Grenoble, France) talked about closely related items in his review of quantum interference effects in small systems, both in the context of normal and of superconducting networks. Emphasis was placed on the possible use of networks made of micron-dimensional (or even submicron) units. These circuits were built by Rammal's group in order to study basic physical phenomena such as frustration, weak localization, and enhanced backscattering in disordered materials.

The intriguing talks by C. Flytzanis on optical nonlinearities in small particles and composite materials reported on studies and research done at the Laboratoire d'Optique Quantique du CNRS, École Polytechnique, Palaiseau, France. He pointed out that, because of basic quantum theoretical limitations, not much progress can be expected in developing new bulk materials with very high values of nonlinear optical susceptibilities if maintenance of other good bulk properties is also desired. Therefore, a different approach has been recently proposed: it



consists in artificially enhancing the nonlinear optical coefficients by the use of inhomogeneous (and in particular composite) materials, where small metal or semiconductor particles are dispersed in a transparent dielectric, such as a glass or even a liquid. This approach not only allows an optimization of nonlinearity, size, response time, and mechanical and thermal properties, but also may lead to new types of nonlinear effects. Flytzanis presented the main aspects of optical nonlinearities in glasses doped with small-grained metallic or semiconductor crystallites, and also in the corresponding colloids. New effects in the nonlinear propagation in inhomogeneous media (such as intensity autolimitation, self-transparency, pulse reshaping, and pulse shortening) were also given much attention. These effects arise from a balance between nonlinear refractive index changes and loss through light scattering. Special attention was given to the enhancement of optical nonlinearities through resonances, and to the role of light-induced modification of the electron density distribution. Flytzanis also reminded the attendees that the study of nonlinear optical properties of composite materials is relevant also to other aspects such as properties of small aggregates or clusters which are likely to play an important role in the next generation of miniaturized devices. This is so because the small size of the aggregates (10 to 1000 Å) may lead to zero-dimensionality effects.

The contribution of J.P. Nougier (Centre d'Électronique de Montpellier, Université du Languedoc, Montpellier, France) discussed the problem of noise in small devices, and described powerful new methods for modeling noise. A substantial part of the lectures had a tutorial ring: basic definitions for noise quantities were recalled, and the expressions for the noise sources were given. Subsequently, the impedance field method and its practical application was explained. Special attention was given to the use of the local field or local voltage entities. Examples were taken from the realm of one-dimensional unipolar devices. Nougier noted that, unfortunately, the extension of the new method to two- and three-dimensional structures runs into serious problems: computation-time troubles as well as difficulties of a fundamental nature arise. Applications to submicron devices were also discussed, including nonstationary effects. Unfortunately, in this area bad fundamental problems are met: not even the modeling of first-order characteristics is presently possible, hence it is really hopeless to devise acceptable noise modeling.

#### Remarks

The manuscripts of the four presentations are available at ONRL and, upon request, I will be glad to make copies for personal use. The Proceedings of the complete winter school were published by Springer-Verlag in the late summer.

Paul Roman  
8/15/86

#### WOPPLOT 86: AN UNUSUAL MULTIDISCIPLINARY WORKSHOP ON PARALLEL PROCESSING

The second European meeting, "Workshop on Parallel Processing: Logic, Organization, and Technology," took place at the University of the West German Armed Forces, at Neubiberg, near Munich, from 2 through 4 July. Apart from the multi- and interdisciplinary nature of the meeting the most amazing surrounding circumstance was that, with a few exceptions, the participants were neither computer scientists nor hardware (microelectronics) engineers: instead, most of them were renegade theoretical physicists.

Only 28 invited people attended, and 15 talks were presented--each lasting a full hour. (Proper time for discussions was included in each presentation.) The participants were West Germans and Italians. One Polish scientist was also present. (A list of participants with addresses is available from me.) Clearly, the setup of the meeting reflects personal arrangements--and indeed this was the most informal yet well-disciplined meeting that I have attended for decades. There were tremendous gains in this arrangement but also difficulties for an observer. No abstracts were provided, no records were taken. However, the detailed texts of talks are to be published by Springer, in the series *Lecture Notes in Computer Science*. This volume is now available--fast publication is a hallmark of Springer.

It is not easy to group the talks into meaningful "sessions"--there were no formal arrangements. But I think it fair to say that the presentations had three focal areas, to wit:

1. Structural, conceptual, framework-considerations
2. Operational and realizational concerns
3. Technical developments.

I give only a "by title" summary of talks in each area which, due to my personal predilections, caught my interest.

#### Conceptual Considerations

The keynote address of the entire workshop was given by E. Caianiello



(University of Salerno, Italy). He talked about the mathematical theory of neural nets and cellular automata and treated the latter as a special case of the former. J. Becker (University of the Bundeswehr, Neubiberg, West Germany), who was the organizer of the workshop, talked about "Structure and Parallel Processing," going into many philosophical aspects of the role and importance of structure. G. Scarpetta (University of Salerno) gave a lecture on self-organizing hierarchical modular systems. There were also two esoteric presentations in this group of contributions. One, really in the area of psychology, given by P. Molzberger (University of the Bundeswehr) addressed the problem of analyzing mental representations by means of "neurolinguistic programming" and applying these ideas to the purposeful training of "super-programers." The other peculiar talk was purely in the area of philosophy. A. von Müller (Max Planck Workgroup, Starnberg, West Germany) talked on his views as to how to arrive at a complex (nonlinear, nonlocal) notion of time.

#### Operational Researches

A highly professional overview of current and planned research on pattern storage for image analysis was given by M. Forshaw (University College, London, UK); his talk was entitled "Pattern Storage in Quasi-neural Networks." Somewhat related to Forshaw's talk was the presentation by V. Cantoni (University of Pavia, Italy), with the title "Pyramidal Architectures for Image Processing." G. Mauri (University of Milan, Italy) gave a deep mathematical analysis of intrinsic parallelism of problems. G. Brewka (Association for Mathematics and Data processing, GMD, Birlinghoven, West Germany) demonstrated the application of nonmonotonic logic to knowledge representation.

#### Technical Researches

The only talk on existing microelectronics devices was given by I. Eisele (University of the Bundeswehr), the chairman of the entire workshop. He described new and planned technological developments for fabricating three-dimensional circuitry. The main tool would be advanced molecular beam epitaxy. Finally, M. Mehring (University of Stuttgart, West Germany) led the audience into the hoped-for land of the far future: he talked about molecular electronics, discussing in particular the physical aspects of transport and storage in engineered, large organic molecules.

#### Comment

Even though the meeting was eclectic and highly individualistic, it served a good purpose and certainly it was an un-

usual stimulant to the intellectual appetites.

Paul Roman  
8/15/86

#### SECOND INTERNATIONAL SYMPOSIUM ON ANALYSIS AND DETECTION OF EXPLOSIVES

On the first day of the Second International Symposium on Analysis and Detection of Explosives, I noticed a number of the Ph.D.-trained participants were carrying handguns in the waistbands of their trousers. This was clearly not the usual 6.1 research community.

The symposium was held from 29 June through 3 July at Neurim, Israel. The Israel National Police Academy is in Neurim, on the coast about 15 miles north of Tel Aviv. The meeting was sponsored jointly by the Israel National Police and the Weizmann Institute of Science in Rehovot. The two are quite different institutions with rather different mandates. However, they seemed to have collaborated smoothly in this case--a tribute to the skills of the organizing committee and another indication that an effective response to world terrorism requires close cooperation across disciplines and countries.

The first of the symposia had been convened by the Federal Bureau of Investigation (US) and held in Quantico, Virginia, 3 years ago. Though professionals involved in explosives analysis and detection have their own specialized scientific and technical gatherings, it was felt then that there was no international forum where specialists from different fields could gather to compare notes. Thus the first and second symposia were held and a third symposium is tentatively scheduled for West Germany in 1989. While these meetings are unclassified, attendance is by invitation, and the isolated meeting sites and common dining room arrangements are conducive to informal discussions. Twelve countries were represented by approximately 100 participants, about half of whom were Israelis; a large contingent came from the US.

The scientific content of the meeting can be simply divided: detection (before an explosion) and analysis (after an explosion). Most talks were devoted to the latter and stressed the forensic aspects. Since the proceedings will be published soon in the *Journal of Energetic Materials* and the conference program is given in Table 1, my remarks will be general.

Postexplosive analysis is characterized by small quantities of residual explosives (ng to mg quantities) and relies upon wet chemical techniques, high-performance liquid chromatography and

mass spectroscopy. In addition to identification of the explosives, great effort goes into reconstructing the timing mechanism and geometry of the explosive device. Such information can point, in

Table 1

## Papers Presented at the Symposium

Opening Session

"Development of Novel Energetic Materials," J. Alster, US Army Research and Development Center, Dover, New Jersey.

"Explosives Residue Analysis in the Mid-1980's--An Expanding and Challenging Role for the Forensic Scientist," A. Beveridge, Royal Canadian Mounted Police, Vancouver, BC, Canada.

Decomposition and Mechanism Studies of Explosives

"Decomposition Products of PETN in Post Explosion Analysis," A. Basch, E. Grushka, S. Abramovich-Bar, Y. Bamberger, D. Daphna, T. Tamiri, and S. Zitrin, Israel National Police, Jerusalem, Israel.

"Detonation Gases and Residues of Composite Explosives," F. Volk, Fraunhofer-Institut für Treib- und Explosivstoffe (ICT), D-7507 Pfinztal-Berghausen, Germany.

MS/MS of Energetic Compounds. A Collisional Induced Dissociation

"Study of Some Polynitrobishomocubanes," Y. Yinon, Weizmann Institute of Science, Rehovot, Israel, and S. Bulusu, US Army Research and Development Center, Dover, New Jersey.

Analysis of Explosive Residues

"The ATF Approach to Post-Blast Explosives Detection and Identification," D.D. Garner, Bureau of ATF, Rockville, Maryland.

"Determination of Oxidizing Anions in Explosive Mixtures by Phase Transfer," B. Glattstein and S. Kraus, Israel National Police, Jerusalem, Israel.

"A Spot-Test Kit for Explosives," T.Z. Hong, C.P. Tang, T.S. Kao, and Y.J. Chen, Chung Shan Institute of Science and Technology, Lung Tan, Taiwan, Republic of China.

"ETK--An Operational Explosive Testing Kit Developed and Used by the Israeli Police," J. Almog, S. Kraus, and B. Glattstein, Israel National Police, Jerusalem, Israel.

"Trace Analysis of Explosives and Firearm Discharge Residues in the Metropolitan Police Forensic Science Laboratory," J.M.F. Douse and R.N. Smith, Metropolitan Police Forensic Science Laboratory, London, UK.

"Improved Reagents for Firing Distance Determination," A. Zeichner and B. Glattstein, Israel National Police, Jerusalem, Israel.

Mass Spectrometry and High Performance Liquid Chromatography

"Post Explosion Analysis of Explosives by Mass Spectroscopy Methods," S. Zitrin, Israel National Police, Jerusalem, Israel.

"Capillary Column Gas Chromatography/Mass Spectrometry of Explosives," T. Tamiri and S. Zitrin, Israel National Police, Jerusalem, Israel.

"Liquid Chromatography of Firearms Propellants Traces," J.B.F. Lloyd, Home Office Forensic Science Laboratory, Birmingham, UK.

"LC-Photolysis-Electrochemical Detection for Nitro-Based High Explosives and Water Gel Formulation Sensitizers," C.M. Selavka and I.S. Krull, Northeastern University, Boston, Massachusetts.

"Detection of TNT and Its Metabolites in Body Fluids of Laboratory Animals and in Occupationally Exposed Humans," J. Yinon and D.-G. Hwang, Weizmann Institute of Science, Rehovot, Israel.

General Analysis

"Identification of Explosives in Soviet Weapons," S. Solomonovici, Rafael, ARDA, Haifa, Israel.

"Analysis of Explosives in the Portuguese Forensic Laboratory," J. Anex, Laboratorio de Policia Cientifica, Lisbon, Portugal.

"Molotov Cocktails' and Similar Devices Used by Terrorists in Israel," S. Tsaroom, Israel National Police, Jerusalem, Israel.

"Differential Pulse Polarographic Analysis of Lead Nitroresorcinates," J. Asplund, Nobel Chemicals AB, Karlskoga, Sweden.

"Explosives Analysis (Pre- and Post-Explosion) by NMR Technique," Y. Margalit, Israel Institute for Biological Research, Ness Ziona, and Israel National Police, Jerusalem, Israel.

Explosive Detection

"Explosive Detection via Nuclear Techniques," T. Gozani, Science Applications International Corporation, Sunnyvale, California, and R.E. Morgado, Los Alamos National Laboratory, Los Alamos, New Mexico.

"Research Program in Explosives Vapor Detection at NRC," P. Neudorfl and L. Elias, National Research Council, Ottawa, Ontario, Canada.

"Vapor Pressure of Explosives," D.H. Fine, C. Dionne, and D. Rounbehler, Thermedics, Inc., Woburn, Massachusetts, and J. Hobbs, US Department of Transportation, Cambridge, Massachusetts, presented by E. Achter, Thermedics.

"Transport and Preconcentration of Explosive Vapors by Liquid Sampling Modules," D.P. Lucero, Consulting Thermodynamicist, Triangle, Virginia, and E.M. Bonczyk, US Army Belvoir RD&E Center, Fort Belvoir, Virginia.

"Vapor Characterization of Water Gel Explosives," J.R. Hobbs, US Department of Transportation, Cambridge, Massachusetts.

Panel I: The Appearance of New Home-Made Explosives in Terrorist Activity

Panel II: State of Art and Future Trends in Methodology of Explosives Detection

some cases, to the country which manufactured the explosives or indicate which book the bomb builder used for his designs.

It seems to me that forensic science is, by nature, rather conservative since it must develop or follow standard procedures which are acceptable in courts of law. Moreover, the level of support is low, except in the national laboratories of countries presented with serious problems. Indeed, one implicit aim of the symposium was to create a network of people to call upon for their particular expertise.

I found the panel discussions quite illuminating; while terrorism is an international problem, its manifestations may be quite different from country to country. For example, in the US there are about 700 bombings per year, but few are the work of organized terrorists. Also in the US, there is a large reservoir of explosives, available legally to ammunition reloaders, as well as about 16 tons of primarily mining explosives stolen on average each year. By contrast, in Israel there are about 300 bombings a year, mostly from terrorists. The small commercial explosive industry in Israel is very tightly controlled, and the bombs are made from stolen domestic military explosives (criminal activity) and military explosives manufactured outside Israel (terrorist activity). Israel also finds quite a few improvised explosives and incendiary devices. From the standpoint of detection and analysis, the two countries see a completely different set of problems, even though the total number of bombings is comparable within a factor of two.

My own interests in this symposium concerned detection. The one detection session was devoted primarily to vapor methods. These work extremely well for the volatile dynamite explosives but have limited success with purely military explosives. The problem is that head space vapor concentrations are low (about 10 parts in  $10^{12}$  for, say, PETN at ambient); the concentration can be diluted another 2 to 4 orders of magnitude in more realistic situations; and, further, the molecules will easily physisorb to surfaces. Progress is being made to increase sensitivity and reduce interferences from benign background. At these low vapor pressures, reliable testing of a detector is difficult. One paper, presented by Dr. E. Achter of Thermedics, Woburn, Massachusetts, discussed a simple portable apparatus designed to generate calibrated levels of vapor. Such a device should prove useful for establishing benchmark performance of different vapor detection systems, including animals.

The remaining detection talk, by Dr. T. Gozani of Science Applications International, Sunnyvale, California, presented an overall review of the general problems of detection and the specific approach of  $^{14}\text{N}$  activation by thermal neutrons. This work is funded by the Federal Aviation Administration (US), which is faced with a domestic airline network comprised of 220 major airports and about 26,000 flights moving 1 million passengers and 3 million bags daily.

In general, the symposium's strength was less in the formal scientific talks and more in the panel discussions and private conversations which linked up specialists in different countries and disciplines. The venue of Israel certainly emphasized, to those of us outside postexplosion analysis, the immediacy of the problems of terrorism.

A.N. Garroway  
Naval Research Laboratory  
8/15/86

#### THE SECOND INTERNATIONAL MEETING ON CHEMICAL SENSORS

There is a general consensus by all nations that technology brings with it both good and bad consequences. The major negative consequence is environmental pollution, which presents serious health hazards to mankind. The international scientific community has banded together in an effort to identify and detect quantitatively those industrial pollutants which are known to affect man's well being. Thus, the solution to these problems involves the direct measurement of the pollutant, using sensors which show both specificity and sensitivity only for the hazard in question. In addition, the practical development of such sensors requires that they be small in size, rugged, and relatively low cost. By its very nature, sensor research is multidisciplinary, requiring expertise in physics, chemistry, and solid-state electronics. Fabrication and packaging of these devices, moreover, puts stringent requirements on materials processing.

The 2nd International Meeting on Chemical Sensors was held from 7 through 10 July at Bordeaux, France. (The 1st was held in Japan in 1983.) These meetings are to be held every 3 years, alternating between Japan, Europe, and North America.

This meeting was divided into nine plenary lectures, 31 oral presentations, and 130 contributions presented in poster

sessions. The sessions were divided into eight groups, reflecting the scope of sensor technology:

1. Semiconductor Sensors. By far the largest number of papers was presented in this area. Semiconductor devices are typified by metal-oxide semiconductors which are coated with a thin metal film of palladium or platinum, which respond to a variety of gases such as hydrogen, oxygen, and carbon dioxide. These devices respond to vapors or gases by means of changes in their surface conductance. They are small in size, rugged, inexpensive, and are commercially available. However, they must be operated at high temperature, and they generally respond to more than one gas or vapor and hence are not specific.

2. Solid Electrolyte Gas Sensors. These devices are essentially electrochemical sensors which require electrolytes to produce a reversible chemical change in the presence of a gas or vapor. They are generally more unstable than the semiconductor sensors and are at this stage more costly to fabricate.

3. Humidity Sensors. Sensors of this kind measure water vapor and require piezoelectric or capacitive transducer substrates on which a polymer membrane or oxide coating has been deposited. These devices show extreme hysteresis and are quite nonlinear over wide humidity ranges.

4. FET Chemical Sensors. These sensors are field-effect transistor devices in which the gate region is coated with a gas-selective membrane or organic polymer whose electronic conductive properties are modified by the gas or vapor. These devices are very popular since they can be constructed using commercial, integrated fabrication techniques and offer the potential of being very small, rugged, and inexpensive. Moreover, they can be used in liquid media for sensing biological reactions. A number of papers were presented which pointed to improved selectivity and stability from previous devices of this kind fabricated only a few years earlier.

5. Ion Selective Electrode Sensors. These devices are generally electrodes coated with an enzyme or polymer which detect the presence of specific ions in the solution phase. They are quite popular for clinical monitoring of calcium and sodium ions *in vivo*. They can be fabricated as very small needles which can be placed into the blood stream to monitor levels of blood sugar, carbon dioxide, and oxygen.

6. Biosensors. Biosensors are fabricated on a variety of transducer substrates (e.g., piezoelectric quartz,

thermistors, ion-selective electrodes, and capacitance and electrochemical cells) onto which a specific enzyme or ion-selective membrane is attached. These devices are widely used in clinical and immunological monitoring studies carried out in hospitals. A number of papers presented results from use of such sensors in actual patient monitoring of various metabolic processes in real time.

7. New Sensing Mechanisms. The session on these mechanisms covered a number of recently developed coating materials which respond to various reagents either chemically or physically. The emphasis of the papers was on the basic mechanisms responsible for the observed changes. The range of mechanisms included ionic, electrochemical, surface plasmon, piezoelectric, and electro-optic.

8. New Devices. The last session emphasized new fabrication techniques, especially the use of microfabrication of small, integrated sensors. Such new devices included the photo polymerization of an integrated, optical-waveguide organic vapor sensor; electrostatic smoke detector; a fiber optic ion sensor; and an improved gas sensing SAW device.

#### Summary and Conclusions

This meeting brought together a widely renowned group of interdisciplinary scientists from over the world. The vast array of chemical sensors available for the detection of pollutants in air, fluids, and biological environments bodes well for the future. Out of this array a small number of devices may well prove commercially viable. A great deal of work lies ahead, however, for improving the selectivity, sensitivity, reversibility, and ruggedness of these devices. Nevertheless, one came away from this meeting with the overall impression that many technological sensor problems have been solved, and a much more detailed understanding between the sensor and its environment has been achieved. For information concerning availability of proceedings, write to Dr. J. Portier, Laboratory of Solid State Chemistry, 351 Cours de la Liberation, 33405 Talence, France.

John F. Giuliani  
Naval Research Laboratory  
8/15/86

#### IONIC TRANSPORT WILL BE THE TOPIC OF 1987 MEETINGS

Ionic transport is the topic of two meetings to be held in 1987 for which

recent first announcements have been made.

The "International Symposium on Polymer Electrolytes" will be held from 17 through 19 June at the University of St. Andrews, Scotland. The meeting will deal with experimental, theoretical, and applied aspects of polymer electrolytes. Attention will be focused on the synthesis and properties of new materials, the mechanism of the conduction process, and practical applications. The 3-day meeting will consist of a series of invited lectures, poster sessions, and round table discussions including short contributions. Papers will be presented in English. Keynote lecturers include:

C.A. Angell (Purdue University)  
M.B. Armand (Grenoble)  
A.V. Chadwick (Kent)  
J.M.G. Cowie (Stirling)  
M. Gauthier (Quebec)  
A. Gandini (Grenoble)  
R.G. Linford (Leicester)  
M.A. Ratner (Northwestern)  
B. Scrosati (Rome)  
I.M. Ward, (FRS Leeds)  
M. Watanabe (Tokyo)  
P.V. Wright (Sheffield)

Accommodations will be in University Hall, University of St. Andrew. The approximate cost of the meeting, which will include single room accommodation (approximately 150 maximum), all meals from dinner on the 16th to breakfast on 20 June, registration fees, and conference dinner, will be £120.00 (\$180.00) for participants and £85.00 (\$128.00) for students and nonparticipants. Deadline for receipt of a statement from those who wish to attend is not later than 31 December 1986. For further information, write: Dr. C.A. Vincent, Department of Chemistry, The Purdie Building, University of St. Andrews, St. Andrews, Fife KY16 9ST, Scotland.

The "6th International Conference on Solid State Ionics" is to be held from 6 through 11 September in Garmish-Partenkirchen, Germany. The scope of the conference is for all experimental, theoretical, and applied aspects of fast ionic transport in pure ionic and mixed conducting solids. Plenary lectures and contributed oral and poster presentations are planned. The conference language will be English. Publication of the conference proceedings is anticipated.

The conference will be held in the Congress House of Garmisch-Partenkirchen, a scenic area in the Bavarian Alps in southern Germany.

For further information about the program, registration, accommodations, and social events, write: Max-Planck-

Institut für Festkörperforschung, Attn: Werner Weppner, Re: Solid State Ionics, 87 Heisenbergstr. 1, D-7000 Stuttgart 80, West Germany.

D.L. Venezky  
8/20/86

#### INTERNATIONAL SYMPOSIUM ON THE PROPERTIES AND APPLICATIONS OF METAL HYDRIDES V; STATE OF THE THEORY

The 5th International Symposium on the Properties and Applications of Metal Hydrides was held in Maubuisson, France, at the end of May. The intent of this meeting was to create interactions between the people involved in basic research and those in applications in energy-related technological areas. The scientific program of the symposium covered fundamental studies in crystal structures, dynamics of hydrogen, physical properties, electronic structure, and thermodynamics properties, as well as applications in surface effects, reaction kinetics, mechanical properties, novel hydride systems, and hydrogen storage.

In this note I will review a small fraction of the presentations which relate to theoretical calculations in metal hydride systems. The full proceedings of the symposium, now in press, will be published in the *Journal of Less Common Metals*.

Presentations in the area of thermodynamic properties dealt with the capability of present theories to predict phase diagrams. Such predictions may be made by: (1) first-principles calculations, (2) phenomenological models, and (3) empirical calculations. W.A. Oates of the University of Newcastle, Australia, concluded that only phenomenology or empiricism can at present be used in the synthesis and analysis of real phase diagrams, while the first-principles methods can only be used for the synthesis of coherent phase diagrams and thus provide only qualitative pictures of phase equilibria in real systems.

A model calculation using the cluster variation method for the H-Nb phase diagram was reported by C.K. Hall of the University of North Carolina. In this calculation the authors considered H/Nb concentrations less than 1, and assumed that the tetrahedral interstitial sites of Nb can be handled by an anisotropic simple-cubic-lattice-gas model which includes pairwise interactions including nine nearest-neighbors. They used two adjacent cubes as the basic cluster and

predicted in good agreement with experiment the  $\beta$ ,  $\epsilon$ , and  $\delta$  ordered phases as well as the  $\alpha$  and  $\alpha'$  disordered phases of NbH.

Several authors reported studies of the electronic structure of metal hydrides. The characteristic of these calculations is that they are either performed on systems with very complicated crystallography or, for the simpler structures, the investigators have the following aims: (1) to compute the heat of formation, (2) to understand the effects of disorder and substoichiometry, and (3) to study the interaction of hydrogen in dilute metal hydrides. In the first category, where complicated structures are investigated, M. Gupta of the University of Paris, Orsay, presented electronic structure calculations of the hydride  $\text{LaNi}_5\text{H}_6$  by the recursion method. The compounds, together with Ti-Fe-H, are the most promising hydrogen storage intermetallic compounds. Using the calculated densities of states (DOS) for  $\text{LaNi}_5$  and  $\text{LaNi}_5\text{H}_6$ , interpretations of photoemission and specific heat measurements were given. In addition, the metal-hydrogen interactions were evaluated from a comparison of the site and angular momentum decomposition of the DOS in  $\text{LaNi}_5$  and  $\text{LaNiH}_6$ . These calculations, although not self-consistent due to the complexity of the crystal structure, are very valuable in providing a semiquantitative picture of the band structure of this technologically important material.

Very accurate, self-consistent electronic energy-band structure calculations using the augmented plane wave (APW) method were presented by A.C. Switendick of Sandia Laboratories, New Mexico. These calculations were performed on Ti, Pd, and Ni hydrides which crystallize in the simpler NaCl and  $\text{CaF}_2$  structures, but yielded the total energy, heat of formation, and equilibrium lattice constant quantities that require great calculational precision. The results, which are in good agreement with experiment, show an exothermic heat of formation for PdH and NiH and a repulsive unbound total energy for  $\text{PdH}_2$  which does not form experimentally. For  $\text{TiH}_2$  a minimum in the total energy was found which was sensitive to the method used to treat the core states in the band calculations.

Papaconstantopoulos and Laufer of the Naval Research Laboratory, Washington, DC, addressed the question of disorder and nonstoichiometry. They used the tight-binding coherent potential approximation method, which is a mean field theory approach based on the assumption that the scattering of electrons from the atom sites of an alloy is, on the average, equal to zero. This theory was ap-

plied on the ternary alloys  $\text{Ti}_{1-y}\text{V}_y\text{H}_x$  and  $\text{Ti}_{1-y}\text{Nb}_y\text{H}_x$  which contain disorder on both the metal and hydrogen sublattices. Having calculated the electronic DOS they found good agreement with specific heat and nuclear magnetic resonance experiments. In their analysis they conclude that certain features of the electronic structure of the dihydrides follow a rigid band picture.

Demangeat and coworkers of the Louis Pasteur University in Strasbourg, France, reported calculations of the binding energy between two hydrogen atoms placed on tetrahedral interstitial sites in the bcc metals vanadium and niobium. They also calculated the binding energy between a hydrogen atom and a substitutional impurity in these metals. Their results show that the hydrogen-hydrogen binding energy is repulsive for nearest- and next nearest-neighbor positions. In Nb they found that the binding energy between H and substitutional impurities is attractive for those impurities located to the left of Nb in the periodic table and repulsive for those located to the right.

Finally, Norskov, of Haldor Topsøe Laboratories in Lyngby, Denmark, discussed chemisorbed hydrogen, interstitial hydrogen, hydrogen diffusion, and hydrogen interacting with defects and impurities by means of an effective medium theory. His theory is a simplified way of calculating total energies for complex low-symmetry systems, based on the observation that the total energy is a unique functional of the electron density of the system and that the energy is stationary with respect to variations of the density around the ground state value. This means that an error made in the density is second order in the evaluation of the total energy. He showed that he obtained a qualitative, and in some cases quantitative, understanding of the above-mentioned processes.

D.A. Papaconstantopoulos  
Naval Research Laboratory  
8/20/86

#### CONFERENCE ON NEW MATERIALS AND THEIR APPLICATIONS, SEPTEMBER 1987

The Institute of Physics (UK) is arranging a conference on New Materials and their Applications at the University of Warwick, England, from 22 through 25 September 1987.

The aim of the conference will be to provide a forum for scientists and technologists concerned with new ideas and

areas of applications in the field of materials. The conference will appeal to those in both the industrial and academic sectors involved in the understanding of materials in relation to their design, manufacture, and application. Topics to be included in the program are:

- Advanced materials
- Joining of materials
- Microstructure and its relationship to properties
- Interfacing of materials (including tribology)
- Materials forming techniques
- Materials in a hostile environment
- Materials characterization, including NDT
- Electrical, electronic, magnetic, acoustic, and optical properties
- Health and safety aspects of materials

The emphasis in each case will be on the physical properties and the physics of applications.

A wide range of speakers have been invited to present papers at the conference; these include Professor A. Challis, D. Birchell (Imperial Chemical Industries), D.H. Bowen (Atomic Energy Research Establishment, Harwell), D. Cristafaro (Metglas), F.N. Cogswell (ICI), Professor A. Cusens (Leeds University), Professor C.H. Goodman (STL), F.L. Matthews (Imperial College), G. Partridge (GEC), Professor A. Vardy (Dundee University).

Contributed papers are invited on the topics listed above or on any other area with the general theme of the conference. Brief abstracts will be required by 15 March 1987 for program selection. The proceedings will be published in The Institute of Physics Conference series.

An exhibition will be organized in conjunction with the conference. Further details about the conference and exhibition are available from the Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SW1, England. Other information can be obtained from me, at ONRL.

Louis Cartz  
8/15/86

#### "RADIATION EFFECTS IN INSULATORS--4"

The fourth international conference in the series devoted to the interaction of radiation with insulating materials will take place from 6 through 10 July 1987 in Lyon, France. The program will cover mainly the topics listed in Table 1.

Table 1

#### Mechanisms

Energy deposition and dissipation  
Stimulated desorption and sputtering  
Radiation damage  
Radiation-induced mixing  
Annealing processes

#### Techniques

Photon irradiation  
Particle bombardment and implantation  
Defect characterization  
Physical and chemical properties

#### Materials

Ceramics  
Oxides  
Glasses  
Ionic crystals  
Polymers  
Organics  
Magnetic materials

#### Applications

Film adhesion  
Plasma erosion  
Microelectronics  
Optoelectronics  
Nuclear waste  
Space sciences  
Biomaterials  
Catalysts

Contributions are being requested on all subjects listed in Table 1; in particular, the organizers encourage papers in rapidly developing areas such as:

- High energy density effects
- Cluster implantation and desorption
- Metastable phases
- Ion beam microlithography
- Ion beam assisted deposition

The conference proceedings will be published after paper review.

Those interested in participating are requested to contact the conference cochairmen, P. Thevenard and A. Perez, Department de Physique des Matériaux, Université Claude Bernard, Lyon 1, France. Further information can be obtained from me at ONRL.

Louis Cartz  
8/11/86

#### ACOUSTICS RESEARCH AT EDF

Electricité de France (EDF) is the French electric power generating monopoly. Of its 120,000 employees, approximately 2500 are involved in research



activities. There are two locations at EDF where fluid mechanics research is taking place. One is the Laboratoire National de Hydraulique (LNH) at Chatou (see ESN 40-4:136-138 [1986]). The other (much smaller) fluid mechanics activity which is the subject of this article, is in EDF's Department of Acoustics. It is located in Clamart, a southwest suburb of Paris.

The 39 employees in the Department of Acoustics are divided between the Industrial Acoustics Division and the Environmental Acoustics Division. My visit was to the Industrial Acoustics Division where my host was Dr. P. Esposito. The staff struck me as being exceptionally young. This was not a illusion created by my own advancing age but rather a fact which came about as a result of the reorganization of the division 4 years ago. Up until that time, the department's activities could be most politely described as classical, with experimental measurements of the relative merits of various sound insulation materials being its sole occupation. Esposito was one of the first brought in to modernize the group and, in particular, to introduce the use of computational methods to understand the mechanisms of noise generation. In fact, a benign purge of the group took place which resulted in the departure of practically all of the veteran staff members. These were subsequently replaced by engineers whose median age I would judge to be 30.

In addition to Esposito's work, which is concerned with computational prediction of noise generation in ducts, there is work going on which involves the propagation of sound in ducts, production of sound by vibrating structures such as turbo-generators, and a group which develops acoustic monitoring techniques for fault diagnosis in rotating machinery. There is close cooperation between Esposito's group and LNH. In fact, three codes which Esposito uses in his calculations (ULYSSE, ESTET, and MACH 1) were developed at LNH. Esposito's group is composed of three engineers, two technicians, and a doctoral candidate.

The work of the doctoral candidate, Mr. J. Franjaud, was my principal reason for visiting the group. Unfortunately he was ill and I did not have a chance to talk with him during my visit. Nevertheless I was able to get much of the information I wanted.

The problem with many current noise predictions codes is that when sufficient "tuning" has been done to obtain realistic noise predictions, it has been found that the results cannot be reliably extended to other geometries. Franjaud's model depends upon the knowledge of the

details of the flow itself, including the turbulence kinetic energy, and involves an extended  $k-\epsilon$  model to which three acoustic-related parameters have been added. (See ONRL report, C-1-86, *GAMM Conference on Numerical Methods in Fluid Mechanics*.) By relying less on empiricism, Franjaud hopes to develop a more generalized and thus more extendable computational model. Of particular interest to Franjaud is the noise produced by large changes in velocity such as those produced at orifices.

In order to validate and guide Franjaud's work, an in-draft wind tunnel having a rectangular test section  $8 \times 10 \text{ cm}^2$  has been built. The test section is 4 m long. Flow rates from 500 to  $2000 \text{ m}^3/\text{h}$  can be obtained by adjusting the throat area of a sonic nozzle located downstream of the test section. The wind tunnel is called "Clarinet." (I noted with some amusement that an earlier wind tunnel of this sort was called "Tuba.") At the present time they have mounted a slot (which can be regarded as a two-dimensional orifice) at the upstream end of the test section. Holes have been drilled in the upper wall to allow the insertion of a hot-wire probe or a microphone. The walls are transparent to allow access for their Dantec LDA system.

This tunnel will also be used to validate acoustic propagation models. For this purpose they have designed a Michelson-type interferometer which will be used in conjunction with a linear photo diode array to correlate the density fluctuations with pressure and velocity fluctuations. This work is being done in collaboration with the Institut Franco-Allemand de Saint-Louis (ISL).

It was discovered that the flow downstream of the slot is asymmetric and highly three-dimensional. A simulation of the flow was made using the ESTET code. The results were somewhat disappointing. Although the predicted velocity profiles looked similar to the LDV measurements, the predicted levels of turbulence kinetic energy were too low by an order of magnitude. This certainly does not bode well for Franjaud's flow noise predictions since they depend upon an accurate knowledge of the turbulence kinetic energy. Possibly, a three-dimensional simulation (only a two-dimensional case has been run so far) will produce turbulence kinetic energy levels closer to the experimental measurements. Another possibility is that the ad hoc manner in which the density is treated in ESTET may be at fault. The velocities in the jet are certainly high enough ( $M=0.5$ ) that compressibility effects need to be accurately accounted for. Esposito expressed the hope that an EDF code, MACH 1, in

which the effects of compressibility are rigorously treated would give better results. For these calculations it will also be necessary to use a turbulence model which accurately accounts for compressibility effects.

I have the uneasy feeling that the well-documented failures of the  $k-\epsilon$  model to provide accurate predictions of highly separated flow (ONRL report, C-2-86, *Turbulent Shear-Layer-Shock-Wave Interactions*) casts a cloud over the entire computational effort. I am afraid that Franjaud's efforts to develop a turbulence-kinetic-energy-related acoustic model may fail for lack of an adequate turbulence model for such situations.

Eugene F. Brown  
8/11/86

### THIRD INTERNATIONAL SYMPOSIUM ON THE APPLICATIONS OF LASER ANEMOMETRY TO FLUID MECHANICS

The "Third International Symposium on the Applications of Laser Anemometry to Fluid Mechanics" was held from 7 through 9 July in Lisbon, Portugal. The conference was truly international. More than 20 of the papers were from the US and a few less than 20 each from West Germany, France, and the UK. Other countries represented with one or more papers were Italy, Portugal, South Africa, Japan, China, Denmark, Austria, Canada, Spain, Israel, Australia, Belgium, and Sweden. A total of 132 papers were given in two parallel sessions. There was also an open forum where another seven or so papers were given.

The wide application of laser Doppler Anemometry (LDA) in fluid flow measurements was reflected in the broad coverage--some 22 sessions of six to seven papers each. There were double sessions (12-14 papers) for separated flows, two-phase flows, internal combustion, optical systems, and internal flows. Single sessions were devoted to signal processing, boundary layers, combustion, free flows, heat transfer, and turbomachinery and aerodynamics. By far the larger part of the conference was devoted to particles since there were two sessions on particle imaging and three sessions on particle sizing.

The previous two symposia were also held at Lisbon. It is perhaps of interest to indicate some of the technology trends in the application of LDA to fluid flow measurements since the 1982 meeting. This I have done for a few selected

areas of investigation in the paragraphs following.

#### Separated Flows

Before the advent of LDA the measurement of separated flows was very difficult due to the unsteadiness and sensitivities of the flows to probes that might be used in the measurement. With frequency shift the LDA measurements make the determination of turbulent separated flows relatively straightforward. All three symposia, beginning in 1982, had sessions on separated flows. Already in 1982, measurements in forward scatter were made in flows with backward facing steps, furnaces with swirl, with combustion, and turbulent boundary layers. The laser setups were for a single component in forward scatter. In the 1984 symposium LDA use was being reported for two-component measurements to airfoils at high lift, supercritical airfoils, heat exchangers, and further boundary separation in more complicated flows. In this third conference (1986) simultaneous three-dimensional LDA measurements were reported in the wake of bluff bodies. Other more complicated flows involving, for example, two barriers, rapid expansions, vortex structure, were measured. There is starting to appear more theoretical analysis accompanying the measurements. If the purpose of the measurements is to better understand the phenomena, then they should be accompanied by a numerical model. Thus, attention is being directed away from the novelty of the experiment to an understanding of the basic fluid mechanics.

#### Turbomachinery, Aerodynamics, and Internal Combustion Engines

Clearly, measurements in turbomachinery, aerodynamics, and internal combustion engines are another active LDA area. The progression in these areas has been similar to that in separated flows. In particular the work in the measurement of internal combustion engines has progressed from simplified model studies to detailed studies of modified production engines. Realistic measurements are being obtained which should be basic to the direction of future research in this area. Essentially the same comments can be made in the turbomachinery area. The experimental measurements have provided the basis for further modeling of secondary flows in turbomachinery. What would appear to be needed now is coordinated theoretical and experimental investigations of turbomachine flows with a view of improving particularly off-design performance. In aerodynamics there is a problem of measurements in the center of a vortex. Several papers looked at the

problem with some success. The essential difficulty is that the centrifugal force of the vortex sweeps out all particles from the center of the vortex. Thus there is no return signal.

#### Optical Systems

In the 1982 conference new optical methods included discussions of long-range LDA (20 m to 200 m) and a detailed outline of the use of fiber optics in LDA. In the second conference (1984) there was further discussion of long-throw LDA and a paper on the simultaneous measurement of velocity and particle size. Further work was reported on measurements with fiber optics. Detailed reviews were also presented on the three-dimensional laser velocimeter and on the application of LDA to high-speed flows. A report was also given on a laser gradient anemometer. In the present conference (1986) there were papers on multipoint fiber LDA, beam scan LDA, miniature solid-state photodetectors, and LDA using laser diodes. The multipoint method appears to have the greater utility.

#### Particle Imaging

The sessions in the 1986 conference on particle imaging were a new addition. Most of the papers in these sessions were based on the idea of the particle image velocimeter. This concept goes back to about 1982. Essentially, one forms a sheet of laser light in the flow. If the laser light is then double-pulsed, separate particle images can be formed at two slightly different times. From the resulting interference pattern the investigator can determine the velocity and direction of the particle. Instead of having the velocity at a given point, as in the conventional LDA, the velocity can be determined simultaneously over the two-dimensional sheet which was created by the laser. Although essentially two-dimensional, the technique has great merit in determining the large-scale structure of the flow. Thus, vortex patterns are easily distinguished in unsteady flows. This is an exciting technique and perhaps nine papers were devoted to the application of it to different flow fields.

There were three sessions on particle sizing. There is a lot of interest in this area and there have been several recent conferences which also have extensive articles on particle sizing. One experiment that was particularly neat involved the simultaneous measurement of velocity and particle flow in a separated two-phase flow.

#### Summary

The technical level of the presentation was in general quite high. Many of

the experiments were beyond the demonstration stage and were supplying realistic data in the area of combustion, heat transfer, and boundary layers and other areas, as previously indicated. It is further clear that LDA measurements are forming the foundation upon which future advances in fluid mechanics are to be based. In this respect it is hoped that the next conference places greater emphasis on experimental measurements combined with theoretical modeling of the flow field under investigation. It must be admitted that this latter step may prove very difficult in certain flow fields.

Conference proceedings are available. A hard bound volume of selected papers will also be produced as in the case of the previous two conferences. Readers should contact me for further information, if required.

*Daniel J. Collins*  
8/25/86

#### COASTAL ENGINEERING AT THE TECHNICAL UNIVERSITY OF DENMARK

The Technical University of Denmark is located in the town of Lyngby, about 15 miles outside of Copenhagen. It is a small school by American standards, having a total enrollment of about 5000, but all of these are involved in graduate level programs. All the programs at the university appear to be engineering oriented and, as such, are supported by rather extensive technical facilities.

The university is divided into a number of institutes, each of these divided into departments. The Coastal Engineering Department within the Institute of Hydrodynamics and Hydraulic Engineering is a relatively small group consisting of 11 permanent faculty members. However, these 11 faculty members are active in a number of diverse projects, most of them having to do with coastal structures and the effects of waves and currents on these structures. Much of this effort is directed toward the oil industry since Denmark, being a small country, is very interested in developing its offshore oil fields to the maximum extent.

The facilities available are quite impressive, including a number of tanks and flumes housed in a very large building. One of the larger flumes uses an oscillating platform for the object under study to reproduce the effect of very large amplitude waves with a minimum expenditure of energy. At the time I was

there, the Danish Technical Institute (a private engineering firm) was running a series of tests on submerged pipe sections and measuring the stresses when these sections were placed on the bottom and subjected to various wave and current conditions. In addition to this large tank was a coastal tank, a number of wave tanks (all capable of generating wave spectra in addition to single waves), and a tank designed to measure the effect of stratified flow. The size of the facility may be envisioned by the fact that the pumping capacity of this facility, including all the tanks and flumes, is equal to the water-supply pumping capacity for the city of Copenhagen.

Although the facilities are quite large and impressive they showed their age. They are only about 10 years old, but yet the associated instrumentation has the appearance of being much older. Computer facilities were available, but they were minimal and gave the appearance of being added on after the building was designed. Wires ran everywhere from various platforms to the small instrumentation room in the center of the building. All the moving model carriages and platforms from which data were acquired were hard wired to the computers, so that a great mass of flexible lines was required. I got the distinct impression that The Institute of Hydrodynamics and Hydraulic Engineering is experiencing some severe problems in making the transition to the "computer age."

Lastly, there did not appear to be any facilities for the generation, or measurement, of wind-generated waves at this institution. This is a difficult subject area, but nevertheless it was surprising to see no evidence of attention to laboratory studies of this important aspect of coastal engineering.

*Jerome Williams*  
8/15/86

#### GEOPHYSICAL FLUID DYNAMICS AT CAMBRIDGE UNIVERSITY

I visited the Department of Applied Mathematics and Theoretical Physics (DAMTP) and the Engineering Department at Cambridge University on 18 June this year and was impressed with the work going on there in fluid dynamics.

The Department of Applied Mathematics and Theoretical Physics was formed in the early 1950's. It was headed initially by George Batchelor, who retained that position until very recently when Keith

Moffatt succeeded to the chair position. Batchelor was, of course, a fluid dynamist of world renown, and during his period as chairman this discipline was emphasized very strongly. Even in recent years with a chairman whose interests lie elsewhere, the group in the department interested in oceanography, meteorology, and geophysical fluid dynamics is still extremely active, representing a major portion of the worldwide effort in geophysical fluid dynamics. At the present time about 25 percent of the staff in the department is devoted to studies in this general area. In addition to these permanent staff members there are postdoctoral, research student, and visiting scientist positions, all adding to the staff size.

The department's Dr. M. McIntyre, is concerned with the dynamics of the middle atmosphere, a portion of the air column coming under greater scrutiny these days. McIntyre, working with a group that includes three postdoctoral researchers and two Ph.D. candidates, is focusing on wave-induced mean flow. He is using some satellite IR data for input to his models, and much of what he has done previously has been used in the British Meteorological Office's models used in everyday forecasting.

One aspect of the work in Cambridge which is particularly pleasing to me is the amount of cooperation that apparently goes on between departments. McIntyre, for example, is working very closely with a group of physical chemists studying some of the more important processes in the middle atmosphere.

Dr. Julian Hunt has an joint appointment with the Engineering Department and DAMTP. His interests lie in many different areas, but as might be expected from his joint appointment they are sometimes directed towards more practical problems. He is using a statistical approach to look at the distortion of turbulent flows; this is an effort to answer questions involved with the variation of varying pressure disturbances with fluctuating velocity fields. Of particular interest is the change in magnitude of the variation of this pressure fluctuation between large- and small-scale turbulence. Turbulent diffusion is another area receiving attention as he studies the effect of an object placed in a turbulent plume on the diffusion of that plume.

A particularly interesting project from the oceanographic point of view is Hunt's study of airflow over undulating surfaces. Up to this time he has limited his studies to solid, undulating surfaces such as hills and valleys. However, there is no reason to believe that the results

of this effort cannot be carried over to the study of airflow over a surface water wave, and he intends to pursue this line of activity. He is hoping to get a better understanding of the methodology by which energy is transferred from the atmosphere to the water surface and converted to surface waves. He is also looking at turbulent density interfaces associated with the generation of internal waves, and the transfer of turbulence through these interfaces, especially from the ground level atmospheric layer upward or the hydrospheric surface-mixed layer downward through the thermocline.

He has seven Ph.D. students and two postdoctoral appointees working with him, and he is working very closely on the dispersion of toxic materials with Dr. Rex Ritter of the Engineering Department, whom I also visited. All of Hunt's work is in turbulence, in one form or another, but one project having a slightly different bent is concerned with the study of the trapping effects of turbulent vortices on bubbles and particles. This work may very well have some application in near-bottom sediment transport studies and mathematical models of breaking waves.

The last person I visited in the Department of Applied Mathematics and Theoretical Physics was Paul Linden. Dr. Linden is working on density flows and the effect of turbulence on the development and destruction of fronts. He is particularly interested in turbulence in stratified flows, hydraulic control in rotating systems, and the dynamics of meter-scale eddies. He would also like to continue the work in double diffusion that he started some years ago.

Linden's work is heavily supported by a laboratory effort within DAMTP. His laboratory is well stocked with a number of well-designed, small, fluid dynamics experiments, each one carefully conceived for work on a specific group of problems. Nearly ready for operation is a new computer-controlled rotating table. The computer is able to control the rotational speed to about 1 part in a thousand, and the table is large enough to hold experiments about 2 meters in diameter. One of these experiments is a model of the European Mediterranean and the Atlantic Ocean with the sill separating them. The flow between the Mediterranean and the Atlantic is being studied under the influence of Coriolis force. Another physical model that Linden is using in the study of turbulence in stratified fluids is a tank containing a grid that is allowed to move through a density interface, generating turbulence. After this turbulence is distributed throughout the tank by the movement of the grid, the

effect on the density interface may be observed.

The Engineering Department, under the leadership of Rex Ritter, is also interested in fluid dynamics. Most of Ritter's work is experimental, with the theoretical input largely supplied by Julian Hunt of DAMTP. Ritter is concerned with dispersion of toxic materials and has worked with the appropriate British and American groups developing mathematical models. His approach is experimental and his analyses are semiempirical, primarily concerned with buoyancy-influenced flows and their turbulent structure. Based on many years of experience, he is developing a workbook for safety and health managers to help them interpret data and make policy decisions. He has a tank 10 meters long 1 meter deep and 1½ meters wide which presently contains six different layers of water. Each of these six layers can have its velocity and density varied, allowing study of density flows, turbulent layers, and the turbulence produced in stratified fluids. He is also working with turbulent boundary layer structure, using air flow next to a wind tunnel wall with both smoke and stress probes to allow visual monitoring of the flow while numerical measurements are taken. One of the applications of this type of study is to determine the amount of entrainment associated with a leak of toxic material. Ritter is also attempting to make measurements of the concentration fluctuation within the boundary layer.

Generally speaking, these two departments are individually and collectively doing some very interesting work in fluid dynamics at many different scale sizes. One of the things that was encouraging to me was to see theoreticians within the Department of Applied Mathematics and Theoretical Physics using experimental laboratories themselves to complete a cycle of proving theoretical models.

Jerome Williams  
8/15/86

#### OCEANOGRAPHY AT THE UNIVERSITY OF COPENHAGEN

Somewhat separated from the main campus of the University of Copenhagen but located within the city limits, The Geophysical Institute of the University of Copenhagen occupies a compact group of old, renovated buildings. The four departments that make up the institute

are Oceanography, Meteorology, Solid Earth Physics, and Glaciology; each has a staff of about four academic members.

At present the Oceanography Department has an active staff of only two people, K. Nygaard and N. Hojerslev. A third member of the department, G. Kullenberg is on temporary leave, working in Paris for UNESCO. The fourth position is vacant at this time but it is expected to be filled very soon. The department has always been very heavily involved in optical oceanography, since this was the home institute of N. Jerlov, who for years was a world leader in this field. Jerlov is retired now, but his spirit remains in the work being done at the Geophysical Institute.

One of the more active optical programs is concerned with *in situ* color measurements for both upwelling and downwelling light. These measurements are designed to measure the spectral characteristics of ambient light, and although many measurements were made at only two colors, 521 and 451 nm, the system is in the process of being expanded to a total of 12 bands. Dr. Hojerslev has been especially active in this area, since he is interested in the color characteristics of scattered light for remote sensing applications. The department has also been very active in using fluorometry over the last 15 years in the measurement of Gelbstoffe (dissolved yellow organic material: yellow stuff) and chlorophyll *a*, and also in tracking Rhodamine B in various dye studies. The University of Copenhagen people believe that the fluorometric measurements they make relate to a reproducibility of 0.1 mg/m<sup>3</sup> in the measurement of chlorophyll *a*.

Another of their uses of fluorometry is an attempt to trace the origin of water masses from specific rivers by their fluorometric signature. This project has been going on for some time, but is still incomplete.

One of the instruments being developed at the present time is an absorption scatterometer. Scattered light at selected incremental angles from 5 to 175 degrees from the main beam is measured after the scattered light has transmitted a fixed water path. In this manner both absorption and scattering coefficients may be determined. This device can either work in a scanning or profile mode. In the scanning mode it is lowered to a particular depth, and measurement is made of the scattering through the entire range of angles. In the profile mode the device is set for a particular scattering angle and lowered to various depths to determine the variation of scattering at a specific angle with depth.

The major nonoptical project concerning the Oceanography Department at this time is an international one, centered off the east coast of Greenland, designed to study the physical, chemical, and biological characteristics of the region. This project is multinational in character, involving Norwegian, American, and Danish scientists, ships, and equipment. Some preliminary work has been done and planning is underway for a massive effort to examine this area. It is hoped that a suite of unmanned devices to acquire data at various depths can be placed in the water and left there for the winter season. Current meters have already been employed by US and French scientists, and the US is planning a large acoustic tomography effort in the region. The Danish interest is prompted by the fact that there may be oil close in to the coast of Greenland, so oceanographic data are extremely desirable for future use in drilling operations.

The university owns one small vessel, which is used primarily for student instruction in coastal areas. When deep sea work is to be done, university scientists either go aboard vessels of other countries, or else they utilize vessels of other government agencies such as the Institute of Fisheries and Marine Research (a government agency under the Ministry of Fisheries). Another vessel that has been used belongs to the Marine Pollution Laboratory. It is large enough for ocean use but is usually employed in a continuing study of the Denmark straits. The Oceanography Department, in conjunction with the Institute of Fisheries and Marine Resources, is also involved in a multidisciplinary study of the Jutland Current. Physical, chemical, and biological oceanographic data are all being accumulated. Interestingly enough, all marine biology taught at the University of Copenhagen is offered through the Botany and Zoology Departments, while any field work is done at laboratories associated with these departments, rather than the Oceanography Department.

The facilities available to the department, within its own buildings, are typical of any oceanography department primarily interested in physical oceanography. There are a number of flumes and tanks suitable for all sorts of current and wave studies, but the major portion of the laboratory facility is devoted to optical oceanography. The instrument calibration facilities, for example, are probably unique in Europe. There is a large tank (about 3000 gallons) for optical instrument calibration which is fed by a filter system composed of large-capacity millipore filters, so that the

water in the tank is kept super clean. There is also a large, clean, magnetically shielded optical calibration room containing optical benches, standard sources and receivers, and other optical devices all maintained in an antiseptic environment. Laboratory facilities are capped off by a small but very well equipped and neat machine shop utilized for the manufacture and development of new optical instruments. Most of the devices used by the Geophysical Institute are manufactured there.

Although the department is active, it is very small, and one gets the impression that the amount of work being attempted by this small department is probably overwhelming. Some of the new computer-oriented developments in data acquisition and storage, common to many of the larger laboratory facilities, have not been incorporated in the Danish effort as yet. Nevertheless, valuable data is still being acquired by these hard-working and ingenious people.

Jerome Williams  
8/15/86

#### A NEW JOURNAL: BRAIN, BEHAVIOR AND IMMUNITY

An announcement was made at the Second International Workshop on Neuroimmunomodulation held in Dubrovnik, Yugoslavia, in June 1986 that early in 1987, Academic Press will begin publication of a new quarterly journal, *Brain, Behav*

*ior and Immunity (BBI)*. The journal will provide an international forum for the publication of papers dealing with interactions between the nervous system and the immune system at the molecular, cellular, and organismic levels. BBI has an international board headed by Robert Ader, Nicholas Cohen, and David Felten.

Basic research in subhuman animals and clinical as well as experimental studies in humans are appropriate for the journal, which will publish review articles, theoretical essays, and brief commentaries as well as original reports. An invitation was issued for submission of manuscripts to: Dr. Robert Ader, *Brain, Behavior and Immunity*, Department of Psychiatry, University of Rochester Medical Center, 3000 Crittenden Blvd., Rochester, New York 14642, USA, telephone (716) 275-7204.

Claire E. Zomzely-Neurath  
8/22/86

#### ONRL COSPONSORED CONFERENCE

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

Domain Decomposition Methods for Partial Differential Equations, Rocquencourt, France, 5-7 January 1987.

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#### ONRL REPORTS

To request reports, indicate the report number on the self-addressed mailer and return it to ONR, London.

- C-6-86 *Life Sciences Conference "From Enzymology to Cellular Biology,"* by Claire E. Zomzely-Neurath. This report covers presentations on the topics of enzymology, enzyme engineering and biotechnology, metabolic regulation, gene expression and transcriptional signals, and replication. It includes a table showing the scientific program of the conference.
- C-7-86 *2nd International Workshop on Neuroimmunomodulation,* by Claire E. Zomzely-Neurath. The presentations at this workshop emphasized the close interrelationships of the nervous and immune systems. There were 10 sessions: neuroendocrine correlates of neuroimmunomodulation; enkephalins-endorphins; immunomodulators; neuroendocrine receptors in the immune system; neurophysiological correlates of neuroimmunomodulation; stress and immunity; behavior; associative learning and immunity; cancers, AIDS, and immunity; and psychiatric and neurological disorders with immunological features.
- R-5-86 *Aerodynamics Research and Development at the Royal Aircraft Establishment (RAE) Farnborough in the UK,* by CAPT L. Laddie Coburn, USN. This report is a survey of the organization and division of the functions of the RAE research and development. It includes a summary that compares the UK MoD research establishments with the US Navy laboratories.



SCIENCE NEWSBRIEFS FOR SEPTEMBER

The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during September. *Science Newsbrief* provides concise accounts of scientific research developments, meeting announcements, and science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

| <u>Science Newsbrief Number</u> | <u>Title</u>  |
|---------------------------------|---|
| 4-10                            | Fluid Mechanics Meetings in Europe 1986-1989  |
| 4-11                            | First International Meeting on Domain Decomposition<br>Methods for Partial Differential Equations |

JUNE JULY AUGUST MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during June, July and August. The *MAS Bulletin* is an account of accomplishments in European naval research, development, test, and evaluation. Its distribution is limited to offices within the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

| <u>MASB Number</u> | <u>Title</u>  |
|--------------------|---|
| 41-86              | ERS-1 SAR Performance Verification  |
| 43-86              | Ship Surveillance--Oil Slicks   |
| 45-86              | Future SAR Processing Capabilities of the German Remote<br>Sensing Center |

OVERSEAS TRAVELERS

Notes on trip reports to locations in Europe and the Middle East which have been received by ONRL are reported below. For details, contact the traveler directly.

Astronomy

*Traveler:* Dr. Jules Aarons, Boston University, Department of Astronomy, 725 Commonwealth Avenue, Boston, MA 02215.

Dr. Aarons acted as Program Director AGARD lecture series 145 on modern HF communications system designs (available as "Propagation Impact on Modern HF Communications Systems Design, AGARD LS-145).

Concerning backscatter measurements at HF, he worked briefly at Laboratoire de Physique de l'Exosphere with M. Bourdillion of Professor Garnier's Group.

In the UK with A. Rodger of the British Antarctic Survey, Dr. Aarons compared observations of F layer irregularities for Argentine Islands and the Boston area with ionospheric intersections.

Computer Science

*Traveler:* Dr. Yu-Chi Ho, Division of Applied Sciences, Harvard University, Pierce Hall, Cambridge, MA 02138.

Attended International Teletraffic Analysis and Computer Performance Evaluation Conference, June 1986, Amsterdam. This was a small, exclusive conference involving leading workers in communications networks and computer system performance evaluation. There was a total absence of East European and Communist Block participants. The conference was well-balanced between theory and practice. The writer's main impression from the conference is that modern computer/communication technology is creating systems which far outpace the abilities of the theory to analyze them.

Environmental Sciences

*Traveler:* Dr. Paul Twitchell, Code 1244, Office of Naval Research, Arlington, VA 22217-5000.

Visits to the UK, Norway, and Denmark in May 1986 are the basis of this report. The focus of the trip was on high latitude environmental research. Information is given on research management and questions of science and technology.

One conclusion from discussions concerning research management is that the trend is continuing for European government agencies to be commercialized. In science and technology, subjects discussed include arctic storms, marginal ice zone meteorology, ocean waves, and remote sensing. Some detail is given about presentations at the Polar Low Conference held in May in Krokkeiva, Norway.

## SUBJECT INDEX FOR VOLUME 40, ESN ISSUES 1 THROUGH 11/12, 1986

The articles are listed chronologically under the subject heading, with title, author, and issue page numbers. Thus, 6:211 indicates issue 6, page 211 of volume 40.

ACOUSTICS

- |   |       |                    |
|---|-------|--------------------|
| Shallow Water Acoustics at the UK's<br>Royal Aircraft Establishment   | 1:1   | J. Thomas Warfield |
| Acoustics Research at the Institute for<br>Sound and Vibration Research, Univ-<br>ersity of Southampton, UK | 6:189 | J. Thomas Warfield |

BEHAVIORAL SCIENCES

- |  |        |                  |
|--|--------|------------------|
| Educational Psychology in Spain                                    | 10:331 | Richard E. Snow  |
| Conference of the International<br>Society of Political Psychology | 11:399 | William D. Crano |

BIOLOGICAL SCIENCES

- |   |       |                           |
|---|-------|---------------------------|
| New ONRL Report Examines Immunology<br>Research in Israel   | 1:7   | Claire E. Zomzely-Neurath |
| Weizmann Institute of Science: Life<br>Sciences Research  | 1:7   | Claire E. Zomzely-Neurath |
| Biotechnology Research at GBF,<br>West Germany  | 2:39  | Claire E. Zomzely-Neurath |
| Biotechnological Activities of the<br>Institute of Technical Chemistry,<br>University of Hannover, West Germany | 2:43  | Claire E. Zomzely-Neurath |
| 7th European Immunology Congress,<br>Jerusalem, Israel  | 2:45  | Claire E. Zomzely-Neurath |
| Biotechnica'85: First International<br>Congress for Biotechnology   | 2:46  | Claire E. Zomzely-Neurath |
| New Team Examines Acoustic Cavitation<br>Generated by Clinical Ultrasound                                       | 2:47  | Claire E. Zomzely-Neurath |
| Center for Biotechnology, Tel-Aviv<br>University, Israel  | 3:79  | Claire E. Zomzely-Neurath |
| Biotec '85 International Conference<br>Exhibition for Bio and Gene Technology,<br>Düsseldorf, West Germany      | 3:81  | Claire E. Zomzely-Neurath |
| First International Conference on Protein<br>Engineering, London, UK  | 3:86  | Claire E. Zomzely-Neurath |
| Center of Molecular Biology, Canto Blanco<br>(Madrid), Spain  | 4:117 | Claire E. Zomzely-Neurath |
| Life Sciences Research at Trent Polytechnic,<br>Nottingham, UK  | 4:123 | Claire E. Zomzely-Neurath |
| Neurobiology Research in Belgium  | 5:149 | Claire E. Zomzely-Neurath |
| Plant Genetics Systems/University/Industry<br>Collaboration   | 5:151 | Claire E. Zomzely-Neurath |
| Biological Science Under TNO--The Nether-<br>lands Organization for Applied<br>Scientific Research              | 6:193 | Claire E. Zomzely-Neurath |
| Center of Immunology, Marseille-Luminy,<br>France   | 6:197 | Claire E. Zomzely-Neurath |
| Life Sciences Research at the Institute<br>for Biochemistry, Free University<br>of Berlin                       | 7:219 | Claire E. Zomzely-Neurath |
| Research at the Institute for Biochemistry<br>and Molecular Biology, Technical<br>University of Berlin          | 7:223 | Claire E. Zomzely-Neurath |
| International Summit Conference on<br>"Neurosciences and Ethics,"<br>Bonn/Jakobsberg, West Germany              | 8:253 | Claire E. Zomzely-Neurath |
| Workshop-Conference on Growth Factors<br>in the Nervous System  | 8:260 | Claire E. Zomzely-Neurath |
| Biotechnology Conference on Biosensors<br>Sponsored by the Royal Society,<br>London, UK                         | 9:301 | Claire E. Zomzely-Neurath |

|  |        |   |
|--|--------|---|
| Life Sciences Conference: "From Enzymology to Cellular Biology"                                      | 10:331 | Claire E. Zomzely-Neurath                         |
| Second International Workshop on Neuroimmunomodulation   | 11:405 | Claire E. Zomzely-Neurath                         |
| <u>CHEMISTRY</u>   |        |   |
| IUPAC International Symposium on Macromolecules  | 1:14   | Oh-Kil Kim  |
| Mass Spectrometry Meetings Held in Wales and West Germany  | 1:15   | Mark M. Ross, Joseph E. Capana & David A. Kidwell |
| Advances in Chemical Reaction Dynamics   | 2:50   | Joyce Kaufman                                     |
| <u>COMPUTER SCIENCES</u>   |        |   |
| Artificial Intelligence at Milan   | 4:126  | Paul Roman  |
| Advanced Computing Theory and Artificial Intelligence Tools Research at Bordeaux                     | 9:305  | Paul Roman  |
| The Transputer and the Language OCCAM  | 9:306  | J.F. Blackburn                                    |
| Conference on Pyramidal Systems for Image Processing and Computer Vision                             | 9:309  | J.F. Blackburn                                    |
| Early Steps Toward an Optical Computer   | 10:338 | J.F. Blackburn                                    |
| ESPRIT Update  | 11:411 | J.F. Blackburn                                    |
| The Second Alvey Conference<br>30 June-4 July  | 11:414 | J.F. Blackburn                                    |
| <u>EARTH SCIENCES</u>  |        |   |
| Geophysics Research in Israel  | 2:52   | Michael F. Shlesinger                             |
| <u>ENGINEERING</u>   |        |   |
| Automation and Robotization in the Welding Industry  | 1:18   | Kenneth D. Challenger                             |
| <u>ENVIRONMENTAL SCIENCES</u>  |        |   |
| EUROMECH 201: Applications of the Mechanics of Granular Materials to Geophysics                      | 5:154  | Chiang C. Mei                                     |
| SPIE Earth Remote Sensing Meeting  | 8:262  | Jerome Williams                                   |
| International Conference on Optical and Millimeter Wave Propagation and Scattering in the Atmosphere | 11:419 | Jerome Williams                                   |
| <u>MATERIAL SCIENCES</u>   |        |   |
| The 3rd International Conference on Composite Structures: Paisley College of Technology              | 2:21   | Kenneth D. Challenger                             |
| Fiber Composite Research at Paisley College of Technology, Paisley, Scotland                         | 2:54   | Kenneth D. Challenger                             |
| International Research on the Physical Metallurgy of Welding: A Review                               | 2:55   | Kenneth D. Challenger                             |
| Physical Metallurgy Research--An Emphasis on Silicon Metallurgy at the Helsinki Technical University | 2:59   | Kenneth D. Challenger                             |
| École des Mine de Paris--France's Premier Academic Center for Materials Research                     | 3:95   | Kenneth D. Challenger                             |
| Ceramic Matrix Composites  | 4:130  | Kenneth D. Challenger                             |
| Fracture Research at the Fraunhofer-Gesellschaft für Werkstoffmechanik                               | 5:157  | Kenneth D. Challenger                             |
| Institut de Soudre: The French Welding Institute   | 5:162  | Kenneth D. Challenger                             |
| Composite Materials Research in Two French Universities  | 6:201  | Kenneth D. Challenger                             |
| Fracture Mechanics and Welding Research at the Technical Research Center of Finland                  | 6:203  | Kenneth D. Challenger                             |

|   |        |                   |
|---|--------|-------------------|
| Ion Beam Modification of Materials,<br>IBMM 86  | 11:425 | Louis Cartz       |
| Tribology Research at the Metal Research<br>Institute of TNO  | 11:429 | Irwin L. Singer   |
| <b>MECHANICS</b>  |        |                   |
| EUROMECH 199--Eddy Simulation of Turbulent<br>Flows   | 3:98   | Eugene F. Brown   |
| Fluid Mechanics Research at the University<br>of Manchester Institute of Science<br>and Technology                              | 3:100  | Eugene F. Brown   |
| Fluid Mechanics, Combustion, and<br>Hydroacoustics at Berlin  | 4:133  | Eugene F. Brown   |
| Fluid Mechanics Research at Laboratoire<br>National d'Hydraulique   | 4:136  | Eugene F. Brown   |
| The First International Conference<br>on Laser Anemometry   | 5:165  | Eugene F. Brown   |
| Informal Turbulent Flow Meeting   | 5:169  | Eugene F. Brown   |
| INRIA Conference on Computing Methods<br>in Applied Sciences and Engineering  | 5:171  | Eugene F. Brown   |
| Fluid Mechanics at NLR  | 7:230  | Eugene F. Brown   |
| Turbulence Research at the Delft<br>Hydraulics Laboratory   | 7:235  | Eugene F. Brown   |
| Turbulence Research at the Eindhoven<br>University of Technology  | 7:237  | Eugene F. Brown   |
| Turbulence Research at IMFL   | 7:239  | Eugene F. Brown   |
| Colloquium on Turbulent Compressible<br>Flows   | 8:266  | Eugene F. Brown   |
| Aerodynamics Research at Messerschmitt-<br>Bölkow-Blohm   | 8:269  | Eugene F. Brown   |
| The Aerodynamics Institute at RWTH  | 8:273  | Eugene F. Brown   |
| Fluid Mechanics Research at DFVLR   | 9:313  | Eugene F. Brown   |
| Symposium on Finite Element Methods<br>and Flow Problems  | 10:342 | Eugene F. Brown   |
| European Turbulence Conference  | 11:433 | Eugene F. Brown   |
| Fluid Mechanics Research at Selected<br>Universities in Portugal  | 11:436 | Daniel J. Collins |
| <b>OCEAN SCIENCES</b>   |        |                   |
| Oceanography Research at Two UK<br>Universities   | 7:241  | Jerome Williams   |
| Oceanography Research at Southampton<br>University  | 8:275  | Jerome Williams   |
| Wave Modeling Colloquium  | 8:276  | Jerome Williams   |
| 18th International Liège Colloquium   | 10:347 | Jerome Williams   |
| Columbus Ocean Workshop   | 11:449 | Jerome Williams   |
| EARSEL Symposium  | 11:443 | Jerome Williams   |
| Satellite Observations of Ocean Color<br>for Dynamics and Biological Studies:<br>Presentations at the 26th Meeting<br>of COSPAR | 11:447 | Jerome Williams   |
| <b>PHYSICS</b>  |        |                   |
| Small Conference on Quantum Electronics   | 1:24   | Paul Roman        |
| Very Short Laser Pulse Research at TUM  | 1:25   | Paul Roman        |
| A Conference on Guided Optical Structures<br>and Their Applications   | 2:60   | Paul Roman        |
| Optoelectronics Research at Oxford<br>University  | 2:64   | Paul Roman        |
| Optoelectronics Researchers Occupy an<br>Island in the Venetian Lagoon  | 2:68   | Paul Roman        |
| Advanced Laser Development at the<br>Clarendon Laboratory   | 3:102  | Paul Roman        |
| Free Electron Laser Theory and Novel<br>Solid State Laser Development at<br>Milan's Academia                                    | 3:104  | Paul Roman        |
| Optical Research at Uppsala University  | 3:107  | Paul A. Temple    |

|   |        |                       |
|---|--------|-----------------------|
| Lasers and Electro-Optics at CISE in Milan  | 4:139  | Paul Roman            |
| Military Applied Laser Research at<br>FIAR of Milan   | 5:175  | Paul Roman            |
| Optoelectronics, Quantum Optics, Quantum<br>Electronics and Instability Research<br>in Florence     | 5:178  | Paul Roman            |
| Charge-Density Wave Studies in Natural<br>Low-Dimensional Materials at<br>Bristol University        | 6:207  | Paul Roman            |
| UK Pulsed-Power Group Formed  | 6:209  | Anthony E. Robson     |
| The 50th Annual Meeting of the<br>German Physical Society   | 7:243  | Paul Roman            |
| International Colloquium on X-Ray Lasers,<br>Aussois, France  | 8:283  | John Apruzese         |
| Garching Revisited--Progress in Quantum<br>Optics and Related Fields                                | 8:287  | Paul Roman            |
| Applied Solid-State Technology Research<br>at Pasing  | 8:290  | Paul Roman            |
| Current UK Trends in Atomic and Molecular<br>Physics Reviewed at the Aberdeen<br>Conference         | 9:318  | Paul Roman            |
| Thin Film Research at the University<br>of Bordeaux   | 9:322  | Paul Roman            |
| An Interesting Topical Conference<br>on Integrated Optics   | 10:352 | Paul Roman            |
| Theoretical Work on Laser-Induced<br>Scattering, Atomic Physics, and<br>Wiggler Design at Innsbruck | 10:355 | Paul Roman            |
| Laser Spectroscopy Serves Basic Research<br>at the University of Graz                               | 11:451 | Paul Roman            |
| The 6th European Symposium on<br>Optoelectronics: A Mixed Bag                                       | 11:453 | Paul Roman            |
| <br><u>SCIENCE POLICY</u>   |        |                       |
| Fraunhofer-Gesellschaft   | 5:183  | Kenneth D. Challenger |

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1985-86 SCIENCE NEWSBRIEFS

Science Newsbriefs are listed by subject, with title, volume, and author. Thus 4-8 indicates volume 4, number 8.

ACOUSTICS

|  |     |                    |
|--|-----|--------------------|
| International Conference on Fluctuation<br>Phenomena in Underwater Acoustics             | 4-4 | J. Thomas Warfield |
| Short Course on Adaptive Signal<br>Processing with Applications<br>to Underwater Systems | 4-5 | J. Thomas Warfield |

BIOLOGICAL SCIENCES

|   |     |                           |
|---|-----|---------------------------|
| Mini Leak® A New and Easily Activated<br>Gel for Preparation of Stable<br>Immunoabsorbents and Affinity<br>Matrices | 4-2 | Claire E. Zomzely-Neurath |
|---|-----|---------------------------|

MECHANICS

|  |      |                 |
|--|------|-----------------|
| Seminars in Fluid Mechanics at the<br>University of Cambridge, UK      | 4-3  | Eugene F. Brown |
| Fluid Mechanics Meetings in Europe<br>1986-1987                        | 4-7  | Eugene F. Brown |
| Seminars on Fluid Mechanics at the<br>University of Cambridge, England | 4-8  | Eugene F. Brown |
| Fluid Mechanics Meetings in Europe<br>1986-1989                        | 4-10 | Eugene F. Brown |

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First International Meeting on Domain  
Decomposition Methods for Partial  
Differential Equations

4-11

Eugene F. Brown

OCEAN SCIENCES

Seminars on Geophysical Fluid Dynamics  
at the University of Cambridge, UK  
Air-Ocean Conference in London Sept '86  
Seminars on Geophysical Fluid Dynamics  
at the University of Cambridge, UK

4-1

LCDR Rich Kelley, USN

4-6

LCDR Rich Kelley, USN

4-9

LCDR Rich Kelley, USN

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1986 ONRL REPORTS

ONR, London, reports are listed by subject, with title, report number, and author. Reports with the "C" prefix discuss European and Middle Eastern conferences; the "R" prefix indicates reports that provide detailed examinations of research.

BIOLOGICAL SCIENCES

Workshop Conference on Growth Factors  
in the Nervous System  
Life Sciences Conference: "From  
Enzymology to Cellular Biology"  
2nd International Workshop on  
Neuroimmunomodulation  
Dubrovnik, Yugoslavia

C-4-86

Claire E. Zomzely-Neurath

C-6-86

Claire E. Zomzely-Neurath

C-7-86

Claire E. Zomzely-Neurath

MATERIAL SCIENCES

Welding Research In Scandinavia:  
An Assessment  
Welding Science and Technology in  
Europe: A Survey and Assessment  
Materials Science in Europe: A  
Summary Report

R-2-86

Kenneth D. Challenger

R-3-86

Kenneth D. Challenger

R-4-86

Kenneth D. Challenger

MECHANICS

GAMM Conference on Numerical Methods  
in Fluid Mechanics  
Turbulent Shear-Layer/Shock-Wave  
Interaction  
Aerodynamic Research and Development at  
the Royal Aircraft Establishment (RAE)  
Farnborough in the UK

C-1-86

Eugene F. Brown

C-2-86

Kenneth D. Challenger

R-5-86

CAPT L. Laddie Coburn, USN

PHYSICS

Current German Laser and Quantum Optics  
Research Reviewed at the 50th Annual  
Meeting of the Physikalische  
Gesellschaft  
Optics '86: Four Western European  
Countries Review Recent Achievements

C-3-86

Paul Roman

C-5-86

Paul Roman



END

12-86

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